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ABSTRACT

From 180 primary children of varied backgrounds half were selected for instruction in conditional logic by means of an audio-tutorial method. At the termination of 15 weekly lessons the experimental students did no better than the control students on our individually-administered conditional logic test ("Smith-Sturgeon Conditional Reasoning Test"), but there was wide variation among age demonstrated mastery of basic principles of conditional logic. Thus, although out methods were not effective in the teaching of conditional logic to young children, many have somehow learned it anyway. In the control group significant relationships between conditional logic ability and verbal intelligence (.6) and socioeconomic status (.4) were found. No significant relationship between conditional logic ability and sex was discernable. (Author)

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CONDITIONAL LOGIC AND CHILDREN
(Cornell Critical Thinking Readiness Project, Phase IIC)

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August, 1969

Final Report

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PREFACE

This work, like many, has been shaped by several people. Although all of us have contributed to all parts of this report, the writing was undertaken as follows: Robert H. Ennis, Chapters 1 and 5; Edward Smith, Chapters 3 and 4; Nancy Wilson, Chapter 2; and Mark Finkelstein, Chapter 6. Nancy Wilson and Mark Finkelstein did the basic statistical analysis of the data.

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CHAPTER 1
THE PROBLEM: CONDITIONAL LOGIC, DEVELOPMENT, AND READINESS

In the course of learning to think critically, we hold that one needs to acquire a mastery of five basic principles of conditional logic. These five principles are fundamental to the notion of a deductive argument of any sort, which in turn is fundamental in all aspects of critical thinking.* In this chapter we shall state, exemplify, and discuss the five basic principles, and attempt to show how crucial they are; we shall explain two questions which concern us about the development of mastery of and readiness to learn these principles of conditional logic; and we shall comment on the relevant literature. The two questions are these: (1) How much conditional logic has been acquired by children, ages 6-9, from a range of socioeconomic backgrounds? (2) Are they ready to learn more?

CONDITIONAL LOGIC

Many types of deductive logic have been identified, but no neat, comprehensive categorization of types of logic has ever been prepared. Kinds which are frequently mentioned include (with some overlapping) propositional (or sentence) logic (which includes conditional logic), class logic, ordinal logic, epistemic logic, alethic logic, deontic logic, spatial reasoning, and mathematical reasoning.

Conditional logic, the kind considered in this study, is so called because the central ingredient in a conditional argument is one or more conditional statements. A conditional statement is one of the form, 'If p, then q', in which 'p' and 'q' represent statements of varying degrees of complexity.

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*See Ennis (1962) for development of the position that deductive logic is fundamental in all aspects of critical thinking.

For example, 'If the handle is up, then the bell does work' is a conditional statement in which 'the handle is up' occupies the place of 'p' and 'the bell does work' occupies the place of 'q'. According to the statement of our example, that the handle is up is a sufficient condition for the truth of the claim that the bell does work; and that the bell does work is a necessary condition for the truth of the claim that the handle is up. The name 'conditional statement' derives from the fact that each part gives a condition for the other part.

The Relation Between Conditional Logic and the Structure of Deductive Argument.

Basic facts about deduction. To begin our attempt to show the close correspondence between conditional logic and the basic argument structure of all types of deductive arguments, we present these five basic facts about deductive arguments.

If an argument is valid, then:

1. The assertion of the premises commits one to the assertion of the conclusion.
2. The denial of the premises does not by itself require the denial of the conclusion.*
3. The affirmation of the conclusion does not by itself require the affirmation of the premises.*
4. The denial of the conclusion requires the denial of the conjunction of the premises (though not necessarily each premise).
5. If the argument's complete premises are the conclusion of another valid argument (called here a "second argument"), then the argument consisting of the first argument's conclusion and the second argument's premises is itself a valid argument.

---

*The qualification "by itself" is intended to exclude the use of information other than the identification of the premises and conclusion.

A deductive argument can be looked at as a conditional statement of the form, 'If p, then q', in which one substitutes the premises for 'p' and the conclusion for 'q', and in which the implication of q by p is logically necessary.

Basic principles of conditional logic. The above principles are parallel to the five basic principles of conditional logic on which this study was focused, providing the basis of our teaching and testing. For each principle assume that a conditional (If p, then q) is given:

1. Basic Understanding (of the Forward Conditional). The affirmation of the if-part (p) implies the affirmation of the then-part (q).
2. Inversion. The denial of the if-part (p) does not by itself imply the denial of the then-part (q).
3. Conversion. The affirmation of the then-part (q) does not by itself imply an affirmation of the if-part (p).
4. Contraposition. The denial of the then-part (q) implies the denial of the if-part (p).
5. Transitivity. Given another conditional (If r, then p) which has for its consequent the antecedent (p) of the first conditional, the affirmation of the if-part (r) of the second conditional implies the consequent of the first conditional (q).

Because the five basic facts about a deductive argument correspond closely to the basic five principles of conditional logic on which we focused, we feel that a grasp of these five basic principles of conditional logic indicates a probable grasp of the basic notion of a deductive argument.*

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*Since many conditionals do not have the logical necessity of a deductive proof, we intentionally weaken our statement with the word 'probable'.

Exemplification of the Five Basic Principles of Conditional Logic.

Using our example we next shall attempt to show the application of the five basic principles of conditional logic to a particular case. In all applications assume that the conditional, 'If the handle is up, the bell does work' ('If p, then q'), is given:

1. Basic Understanding (of the Forward Conditional). Given that the handle is up (p), it follows that the bell can work (q).
2. Inversion. Given that the handle is not up (not p), it does not follow that the bell does not work (not q).
3. Conversion. Given that the bell does work (q), it does not follow that the handle is up (p).
4. Contraposition. Given that the bell does not work (not q), it follows that the handle is not up (not p).
5. Transitivity. Given that the light is on (r), and that if the light is on, the handle is up (If r, then p), it follows that the bell does work (q).

The Distinction Between the Validity Principles and the Fallacy Principles.

Previous studies by the Cornell Critical Thinking Project (Ennis and Paulus, 1965) and by O'Brien and Shapiro (1968) have suggested a vast difference between mastery by children of the validity principles (Basic Understanding, Contraposition, and Transitivity) and the fallacy principles (Inversion and Conversion). The validity principles are so called by us because they specify a valid move in an argument. The fallacy principles are so called because they rule that certain moves are fallacious, though perhaps inviting. Piaget's propensity to lump all these principles together (with other things as well) under the title "propositional logic" thus seems like oversimplification. In contrast we have paid particular attention to the individual principles, and to two groups of principles: validity principles and fallacy principles.

The Meaning of the Word 'If'.

It is difficult to test for skill in conditional reasoning since a person who is alleged to make a fallacy mistake might in fact be interpreting 'if' to mean 'if and only if'. Under such an interpretation the alleged fallacies are not fallacies at all (the denial of the if-part would then imply the denial of the then-part). Given such an interpretation, however, one wonders what linguistic device, if any, the person tested would use for the condition we express by use of the word 'if'.

Not having developed a fully satisfactory way to get around this possible difficulty in interpretation, we make the Whorfian assumption that understanding of the concept of one-way implication is closely related to the use of the one-way interpretation of the word 'if'. This is a crucial assumption on which much of the interpretation of our results depends.

The Suppositional and Factual Application of the Basic Principles of Conditional Logic.

In applying a given conditional one's conclusion can be based upon an additional supposition (which might be contrary to fact), or it can be based upon an additional premise which is believed. We focus on this distinction because our interest was aroused by Piaget's claim that "the child cannot reason from premises without believing in them. Or even if he reasons implicitly from assumptions which he makes on his own, he cannot do so from those which are proposed to him." (Piaget, 1928, p. 252)

The distinction we draw is a psychological rather than a logical distinction. For purposes of determining logical validity the degree of belief in a premise is irrelevant, but in view of the Piaget claim, we do draw a distinction between those situations (called "factual") in which a child is asked to reason from premises, all of which he believes, and those situations (called "suppositional") in which at least one of the premises is "proposed to him".

Using our example, this distinction can be exemplified by the following two situations:

1. A child is shown a model house and taught that if the handle is up, the bell does work (If p, then q). He is asked to suppose that the handle, which is hidden, is up (p). He is then asked whether the bell would work (q) and asked to tell why he answers as he does.
2. A child is then shown the handle, which is up, and is asked to note the position of the handle (p). He is then asked whether the bell does work (q) and asked to tell why he answers as he does.

In the first situation the child is asked to reason from premises at least one of which (the minor premise) is proposed to him (he cannot see the position of the handle and is simply asked to suppose that the handle is up). In the second situation he can see that the handle is up, so he is asked to reason from premises which he believes. As we read Piaget, children under 11-12 cannot do the first kind of reasoning.

In this study, questions of the first type are labeled 'suppositional'; those of the second type, 'factual'. We hope that the word 'factual', which we selected for lack of a better alternative, will not be misleading. The premises in the factual items need not necessarily be true; but they must be believed.

Propositions and Propositional Functions.

In formal logic there is an important distinction between the following two conditionals:

a. If any vinegar is poured on any baking soda, that baking soda will bubble.

b. If this vinegar is poured on this baking soda, this baking soda will bubble.

We shall not go into the distinction in depth, but will simply state that in (a) two propositional functions are joined by the if-then connective, whereas in (b) two propositions are joined by the if-then connective. We shall also observe that (b) follows from (a) (application to a specific case) but (a) does not follow from (b) (generalizing from one case).

In another place one of us (Ennis, 1969) made much of this distinction in discussing Piaget's notion of logic because in Piaget's context generalizing from data was occurring. In the present context, however, we do not pay much attention to the distinction for two reasons:

1. In our examples (a)-type statements hold; hence (b)-type statements also hold. Students are not asked whether they can infer (a)-type statements from (b)-type statements.
2. In our experience in teaching logic, the move from (a)-type statements to (b)-type statements almost always goes unnoticed by beginners.

In ignoring this distinction for present purposes we are roughly assuming that the inference from an (a)-type statement (and, for example, the statement that a particular sample of vinegar is poured on a particular selection of baking soda) is psychologically equivalent (same basic mental process, same difficulty) to the corresponding one using a (b)-type statement.

THE GENERAL DEVELOPMENTAL QUESTION

Assuming that conditional logic is central to all critical thinking, someone planning to teach critical thinking skills will want to know:

> To what extent have 6-9 year olds of various sorts already mastered particular basic principles of conditional logic, as a result of natural-cultural forces?

This question is one of those we ask in this study; it can be subsumed under our general developmental question, which goes as follows:

> How much conditional logic has been acquired by children, ages 6-9, from a range of socioeconomic backgrounds?

This broad question is intended to exclude a concern with what is possible given good teaching. It is instead concerned with developmental progress now--with what we call "natural-cultural development". In the rest of this section we shall attempt to elaborate on this broad question and two more specific questions which we subsume under it, both of which have already been at least suggested. The two more specific questions deal (1) with development of mastery of principles and (2) with suppositional ability.

Principles Studied.

We asked the developmental question about the last four of the five basic principles of conditional logic, omitting the first principle (called "Basic Understanding") because we assumed that if someone cannot answer a simple question calling for the application of that principle, then he has not understood what is going on. For example, if we have shown and told a child that if the handle is up, the bell works; and if we show him the handle in an up position and ask him whether the bell works, his inability to answer the question would be good grounds for our questioning whether we are communicating with each other. In our testing procedures we used such questions to check to see whether we were communicating with the children; we did not rate them on the Basic Understanding Principle; if they did not answer such questions correctly, we took such inability as an indicator that we had not properly taught them the if-then statement and we proceeded to go over it again.

Factors Studied.

Piaget's references only to age seem to oversimplify the problem. Since on the basis of our earlier study of older children we had good reason to suspect that the results would be considerably different for children of differing socioeconomic backgrounds and intelligence levels, we attempted to secure a cross-section of rural, urban, and suburban children, and a broad distribution of socioeconomic levels and intelligence. In our earlier study we found that sex did not appear to make a difference, but thought it worthwhile to check this factor among primary school children. We did not make a deliberate effort to check the "stages" approach to development, since our age range was only three years, and since the "stages" interpretation is a rather vague one, often bordering on untestability.

Mastery.

One reason for focusing on mastery of principles is that our practical interest--the determination of satisfaction of prerequisites--is conveniently expressed in terms of this concept. If a child has mastered the contraposition principle, then he has satisfied one of the prerequisites for instruction about the reasoning processes involved in the acceptance and rejection of hypotheses.

A second reason for focus on mastery is that use of this concept facilitates communication between us as researchers and the consumers of our research, just as the use of the word 'intelligence' as a label for a number of tests facilitates communication. This is not to say that it guarantees communication; there are pitfalls. But for us to say that a child has mastered the contraposition principle in everyday situations tells more about the child than for us to say that he has a score of five on the contraposition items; it even tells more than the statement that he scored five out of six on the contraposition items. Inherent in the statement using the word "mastery" is our implied judgment (on the basis of considerable experience) that a child about whom we declare mastery has demonstrated a high level of competence in everyday situations calling for the application of this principle. No such judgment is inferable from a report of the scores alone. Since such judgments are matters about which reasonable men differ, we of course report the scores as well, and give considerable information about the testing, so that a person with some background in logic can form a judgment for himself.

Operational Definition of "Mastery".

The judgment that we make about mastery is incorporated in the following set of operational definitions of "mastery":

1. If x is given the "Smith-Sturgeon Test of Conditional Reasoning" under standard conditions; then if x gets a score of five or six (out of six) on the items assigned to a given principle, x has probably mastered that principle.

2. If x is given the "Smith-Sturgeon Test of Conditional Reasoning" under standard conditions; then if x gets a score of three or below (out of six) on the items assigned to a given principle, x has probably not mastered that principle.

Following these criteria, we judge probable mastery for a score of five or six, withhold judgment for a score of four, and judge probable non-mastery for a score of three or below.

Actually, these are very strict criteria, as will be seen in the discussion of the test in Chapter 4. No credit was given on an item unless the child gave both a correct answer and a good justification of his answer. Our judgment is thus incorporated in the selection of the number right necessary for assigning mastery and in the evaluation of the reason given for each answer. Careful procedures were worked out, as will be seen in Chapter 4.

The approach to operational definition was worked out by Ennis (1964) for our previous study. He attempts to retain the operationist spirit without tying it to a reductionist view of the meaning of concepts.

Suppositional Ability.

We were also interested in the ability of a variety of children to operate with the basic conditional principles in situations in which one of the premises was "proposed to him". We share with Piaget the belief that a crucial feature of deductive ability is the ability to assume and reason from that which might not be believed. Hence, another aspect of our developmental question is that concerned with suppositional ability.

We do not inquire about mastery of this suppositional ability, for 'suppositional ability' can have a wide variety of applications, just as 'mathematical ability' has a wide variety of applications. (It would be pointless to ask whether a child has mastered mathematics, since there are so many levels of mathematics: simple addition, subtraction, long division, trigonometry, differential calculus, etc.) What we do inquire about is whether any children can reason on the basis of what is proposed to them (even though they do not believe the proposition).

The Term, "Natural-Cultural".

Since we do not want to urge that changes that occur over time are attributable to only one factor, we have adopted the broad label, "natural-cultural", for whatever development that is not the result of deliberate teacher-instituted instruction in the subject matter under study--in this case the principles of conditional logic. The broad term allows for strictly genetic explanations, strictly environmental explanations, and those which appeal to both heredity and environment; but it does rule out development that results from deliberate teacher-provided instruction in that which is developing.

Our terminology does not even require that there be improvement with the passage of time. There can be negative development and zero development.

THE READINESS QUESTION

Although curriculum planners will be helped by knowledge of the degree of mastery of a particular group of students, they would also be helped by knowing whether particular principles can be learned by certain sorts of children. Armed with this information curriculum planners might decide to provide early instruction in a particular logic principle, which is prerequisite for something that they want to put in the curriculum earlier than it would be without this information. On the other hand, they might decide on the grounds of the non-readiness of certain students to learn a particular prerequisite principle, that this cannot be done. And they might decide to put things at a later point than they would without this knowledge. Hence, we ask our readiness question:

> To what extent are a variety of children ready to learn the basic features of conditional logic?

In order to deal with this question we developed a set of teaching materials, thus generating the question:

> Are these teaching materials effective in teaching the basic features of conditional logic to a variety of 6-9 year olds?

A negative answer to the second question would mean that the children in our study were not ready to learn the basic aspects of conditional logic from our teaching materials. It would not necessarily show that these children were not ready to learn from another set of materials. A positive answer to the second question would show that these children were indeed ready, and would invite us to try to develop a way of predicting whether other children are also ready--and to what extent. The concept of readiness here assumed is discussed at some length by Ennis (1967).

THE EMPIRICAL LITERATURE

Although Piaget is the best known commentator on the development of logical ability in young children, many of his claims are deficient for reasons of vagueness, untestability, falsity, or endorsement of mistaken principles of logic. Sometimes it is difficult to know which of these defects actually obtains; that is, about a particular claim one might have to say that it is either untestable or false, depending on how you take what he says. These complaints are developed by Ennis (1969) in a paper called "Piaget's Logic".

The Developmental Question.

To what extent have children, ages 6-9, mastered the principles of conditional logic? Our previous study (Ennis and Paulus, 1965) and the O'Brien and Shapiro (1968) study make clear that Piaget's term, 'propositional logic', is too broad, since it embodies many principles, some of which are much easier than others. One must focus on particular aspects of propositional logic.

Shirley Hill (1961) claimed "to examine the abilities of first, second, and third grade children to derive valid logical inferences from sets of verbal premises" (p. 1) and concluded that they were able to do so. This claim is in conflict with the Piaget claim (1958, p. 1) that children cannot do propositional logic until ages 11-12. Hill's study was touted by Suppes (1965, p. 189) as showing that children of ages six, seven, and eight "are able to deal very effectively with verbal premises that call for hypothetical reasoning and are by no means limited to 'concrete' operations".

O'Brien and Shapiro and Ennis and Paulus note that the Hill study was not concerned with the fallacy principles. All premises that were given to her children provided valid arguments, although sometimes the conclusion was negated (yielding a correct response of "No") and sometimes the conclusion was simply stated (yielding a correct response of "Yes"). There were only two choices: "Yes" and "No". Hill's neglect of the fallacy principles is not inconsistent with the Piagetian tradition, so we do regard her findings as counting against the Piagetian claim that children under 11-12 cannot do propositional logic. But to interpret her results as Suppes does ("are able to deal very effectively with verbal premises that call for hypothetical reasoning...") seems extravagant to us, since she offered no evidence that children in the age group in question are able to distinguish valid from fallacious deductive reasoning, which they certainly should be able to do if they do "deal very effectively with verbal premises that call for hypothetical reasoning".

O'Brien and Shapiro modified some of Hill's items to introduce logical fallacies and found very poor performance on these items, and thus appeared to contradict Suppes' claim. O'Brien and Shapiro, however, regarded their study as something of a vindication of Piaget. They hold that their results "bring into question the challenge that the original [Hill] research gave to Piaget's theory regarding the growth of this kind of logical thinking in children". (p. 11) We do not see that their results do what they suggest, but part of the problem is undoubtedly the murkiness of Piaget's views. On the face of it, the fact that young children do get correct answers to questions about the validity of propositional logic items about 80% of the time does challenge the Piagetian claim that children cannot handle propositional logic. See Ennis (1969) for a discussion of some of the things that Piaget might have meant by his claim.

Neither Hill nor O'Brien and Shapiro organized their study around the specific basic conditional logic principles that provide the structure of our study. The only study that we know of to have done so is our previous study of older children.

A number of other studies bear on the question of the degree of mastery by children, ages 6-9, of principles of conditional logic. Bonser (1910), Burt (1919), Winch (1921), Woodcock (1941, p. 146) and Donaldson (1963, p. 199) can be grouped with Hill, and O'Brien and Shapiro in showing that children of these ages (or younger) can do at least some propositional logic. But none of these studies focuses on the individual basic principles of conditional logic, as we do in this study.

In our previous study of older children, ages 11-17, the mean scores (See Table 1-1) on each of the four basic principles of conditional logic for which we tested (using a paper-and-pencil test) showed consistent superiority on the validity principles as compared to the fallacy principles, and also showed a consistent improvement with age for all principles. These results were secured from students who had not deliberately been taught logic, so far as we knew, and who had a higher mean I.Q. (around 114) than the students in the current study (around 106).

TABLE 1-1
MEAN SCORES ON THE FOUR BASIC TESTED-FOR PRINCIPLES OF CONDITIONAL LOGIC, AS FOUND IN OUR PREVIOUS STUDY*

Grade Level:	5	7	9	11
N =	102	99	80	78
(Fallacy Principles)				
Inversion	1.4**	1.7	2.1	2.2
Conversion	1.2	1.6	2.1	2.0
(Validity Principles)				
Contraposition	3.3	4.1	3.8	3.9
Transitivity	3.4	4.0	4.2	4.5

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*Ennis and Paulus (1965, p. V-16).
**Top score possible: 6. Mean number of correctly answered items is given here.

Applying our criterion for mastery to the original data, we determined the percentage of students who had mastered the principles of concern here. See Table 1-2.

TABLE 1-2
PERCENTAGES OF STUDENTS WHO HAVE MASTERED BASIC PRINCIPLES OF CONDITIONAL LOGIC, ACCORDING TO OUR PREVIOUS STUDY*

Grade Level:	5	7	9	11
N =	102	99	80	78
(Fallacy Principles)				
Inversion	3%	6%	5%	12%
Conversion	2%	3%	4%	3%
(Validity Principles)				
Contraposition	30%	41%	35%	35%
Transitivity	25%	45%	40%	58%

Since the test used in that study was a group paper-and-pencil test, in contrast to the individually-administered concrete-objects test of the current study (described in Chapter 4), attention should primarily be called here to intratest comparisons rather than intertest comparisons. We developed a new test for the current study in order to avoid the reading problem and in order to secure a more complete involvement on the part of the test-takers.

Factors related to logic competence. Not only do the data in Tables 1-1 and 1-2 show a difference between fallacy and validity principles and a somewhat regular improvement as children grow older, they also show that children over 11-12 are not especially good at simple basic conditional logic. Adolescence does not seem to be anything like a guarantee of ability to handle conditional logic.

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*Ennis and Paulus (1965, p. V-18).

One of our concerns in the current study is to correlate age (which is Piaget's favorite factor), mental ability, dwelling area, socioeconomic status, and sex with logical ability. In our previous study we found that sex appeared to be unrelated (as did Burt (1919), Miller (1955), and Hill (1961)). We did not check dwelling area. We found a correlation of .58 with chronological age over an age range of roughly 10-18 years, correlations with Lorge-Thorndike I.Q. ranging around .60, and correlations with socioeconomic status (estimated in the same way as in the present study) ranging around .20. In that study, then, relationships to conditional logic competence were most strong with chronological age and I.Q., with socioeconomic status running a weak third.

Do children, ages 6-9, have suppositional ability? It is difficult to be sure what Piaget meant by denying that the child below 11-12 can "reason from premises without believing in them", or reason from assumptions "which are proposed to him". (1928, p. 252) On the face of it one might think that this denial implies that children under 11-12 cannot reason from premises which they are asked to suppose. The trouble with this interpretation is that it makes the Piagetian claim rather obviously false. In most deductive logic tests given to young children they are asked to suppose the premises (Bonser (1910), Burt (1919), Winch (1921), Donaldson (1963, p. 199), Hill (1961), and O'Brien and Shapiro (1968)). Any success on such tests then would appear to be counter-evidence to the Piaget claim. Success of various sorts was found in the studies mentioned.

A series of studies of the influence of emotionally-loaded material on deductive reasoning ability has been performed on older people (Morgan and Morton (1944), Thistlewaite (1950), Sells(1952), and Gordon (1953), among others). In general, the findings are that many people do not reason as well when their beliefs are opposed to what they are asked to suppose or conclude. An "atmosphere effect" supposedly operates, meaning that the atmosphere (believed truth or falsity) of the premises influences the judgment about the validity of the argument. On the basis of these findings we would expect our 6-9 year olds to do somewhat more poorly on the suppositional than the factual items, but in view of the demonstrated ability of many children to handle suppositional items, we would not expect our children to be totally unable to reason from suppositions.

In our previous study we did not find any difference between older children's ability to handle logical problems in which they were asked to suppose the premises (which were reasonable), and their ability to handle those in which they were given a conclusion which was in clear conflict with the validity status of the argument (e.g., valid argument, obviously false conclusion). Both types required suppositional ability, but the latter types seemed to require more than the former.

The Readiness Question.

To our knowledge no study of the readiness of primary children to learn conditional logic has ever been done. In our previous study of older children we found that the teaching methods we used at that time (outside teacher, twenty periods on consecutive school days, emphasis on both logic and the subject matter being replaced) were of great help to the upper secondary student, but not to the others. Different teachers were used--one for upper secondary, one for lower secondary, and one for upper elementary--and they had distinctly different styles, a factor which was not controlled.

However, all were experienced teachers at the level at which they were teaching. We did not know whether the fact that they were outsiders in the schools involved was a serious problem.

Because of the reputed success which auto-instructional techniques have had in teaching general science to primary students,* and because we had considerable evidence (cited earlier) that there is logical talent among primary children, we decided to try to apply auto-instructional techniques to the teaching of conditional logic in the primary school. Our previous study, like all readiness studies, did not show that students below upper secondary were not ready to learn more conditional logic. All that it showed was that these students were not ready to learn from the type of instruction that we offered at that time. We hoped that auto-instructional techniques might work.

It is our hope that eventually instruction in critical thinking can assume the prevalence of mastery of the basic principles of conditional logic before the end of primary schooling. According to Ennis (1962) and the early discussion in this chapter, although conditional logic is not sufficient for critical thinking competence, it is necessary; it is prerequisite knowledge.

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*Personal communication with Professor J. D. Novak, Director of the Cornell Elementary Science Project.

CHAPTER 2
CHILDREN AND THEIR ENVIRONMENT

INTRODUCTION

Our study was carried out in three elementary schools serving three distinct neighborhoods in a small upstate New York community. The major employers in the urban area in this community are two relatively large educational institutions, several small manufacturing plants which are subsidiaries of large corporations, and the numerous services supporting these. The land outside the urban area is used largely for either agricultural or recreational activities.

One of the elementary schools selected serves the downtown urban area. Though there is some variety in the occupations of parents of the children living in this area, they are largely in those occupations requiring little skill or training. The jobs held are usually those at the low levels of the urban institutions listed above. Some of the families in this urban area are on welfare. About one-third of these children either do not have two parents living together, or have both parents working.

The second school is the elementary portion of a central school which serves a large rural area centered in a small community about fifteen miles from the main urban area. In our sample the occupations of the heads of households varied considerably. Most were employed in the urban area, their jobs ranging from professional to unskilled. Despite the rural nature of the area, only two of our students came from farm families.

The third school selected serves a suburban area. The heads of the households in this area are almost exclusively professionals: doctors, lawyers, professors, or administrators in the various urban institutions.

SELECTION OF SUBJECTS

The sample of children for this study was selected from grades one, two, and three of the schools described on the preceding page. In each school and for each grade two classrooms were chosen in cooperation with the principals of the schools who were asked for classes representative of the school. From one of the two classrooms ten children were selected at random*to be the controls; from the second classroom ten children were selected at random to be experimentals. The latter then received the instruction described in Chapter 3. Over the course of the year it was necessary to add a child to some of the original groups as children left the school for one reason or another. In such cases, care was taken to see that each new child was chosen at random, and had the same experience with regard to the experiment as other members of the group. One exception to the above description was that of the urban school. Here only one classroom was available in each grade; thus both the experimental and the control group came from the same classroom. In this case it was not possible to make additions to the experimental group if a child dropped out.

DATA

For each child the following information was obtained:

a. School (urban, rural, or suburban).

b. Grade level in school (1, 2, or 3).

c. Chronological age.

d. Sex.

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*The random table used is found in William C. Guenther, Concepts of Statistical Inference, McGraw-Hill, 1965.

e. I. Q. score (WISC).

f. An index of socioeconomic status.

g. Scores on the "Smith-Sturgeon Conditional Reasoning Test".

Age, Grade, School, Sex.

The first four items are available from school records. Chronological age was determined as of October 1, 1969, a date which approximates the period during which most of the I.Q. tests were given (throughout September, 1968) and after which the logic instruction program began (early October, 1968). Tables 2-1 and 2-2 summarize the data for sex and chronological age, respectively, for each of the selected groups in the study. Altogether, after dropping three for lack of data, there were 177 children, 87 control and 90 experimental.

I.Q. Scores.

The Wechsler Intelligence Scale for Children was used to obtain I.Q. scores. For each subject the prorated score was used to determine I.Q. This test was administered to all subjects by a group of trained testers immediately before instruction began.*

Table 2-3 summarizes I.Q. data. The mean total I.Q. scores for our subjects tend to increase progressively approximately five points from the urban (mean = 98.9) to the rural (mean = 104.8) to the suburban (mean = 111.9) school. The I.Q.'s from grade to grade, as one would expect, do not change systematically, though the means for the various sample groups subtotaled by grades do vary from a low in Grade 2 experimental of 100.8

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*Those subjects added later to replace dropouts were given the test as soon as they were included in the logic program.

TABLE 2-1
MEAN CHRONOLOGICAL AGES (IN MONTHS)

		School									Subtotals (for each grade)		
		Urban			Rural			Suburban					
		E	C	E&C	E	C	E&C	E	C	E&C	E	C	E&C
Grade 1	N	9	10	19	10	10	20	11	10	21	30	30	60
	M	75.7	75.2	75.4	78.3	78.1	78.2	75.5	78.4	76.9	76.5	77.2	76.9
	S.D.	4.0	3.1	3.5	5.0	4.3	4.5	4.1	4.5	4.4	4.4	4.1	4.2
Grade 2	N	10	10	20	10	9	19	10	9	19	30	28	58
	M	88.7	88.2	88.4	92.5	90.4	91.5	89.6	90.0	89.8	90.3	89.5	89.9
	S.D.	3.5	7.7	5.8	5.6	4.8	5.2	6.4	3.6	5.2	5.4	5.6	5.6
Grade 3	N	10	9	19	10	10	20	10	10	20	30	29	59
	M	103.9	101.4	102.7	99.5	99.9	99.7	100.2	102.6	101.4	101.2	101.3	101.3
	S.D.	7.0	7.1	7.0	4.7	5.1	4.8	4.3	6.1	5.3	5.6	6.0	5.8
Subtotals (for each school)	N	29	29	58	30	29	59	31	29	60	90	87	177
	M	89.9	87.8	88.9	90.1	89.4	89.8	88.0	90.3	89.1	89.3	89.2	89.3
	S.D.	12.7	12.4	12.4	10.2	10.3	10.2	11.4	11.3	11.3	11.3	11.3	11.3

NOTE: 'E' = 'experimental'.
'C' = 'control'.
'N' = 'number of cases'.
'M' = 'mean'.
'S.D.'= 'estimated population standard deviation'.

TABLE 2-2
NUMBERS OF BOYS AND OF GIRLS IN EACH GROUP

		School									Subtotals (for each grade)		
		Urban			Rural			Suburban					
		E	C	E&C	E	C	E&C	E	C	E&C	E	C	E&C
Grade 1	N	9	10	19	10	10	20	11	10	21	30	30	60
	Boys	3	5	8	8	6	14	9	5	14	20	16	36
	Girls	6	5	11	2	4	6	2	5	7	10	14	24
Grade 2	N	10	10	20	10	9	19	10	9	19	30	28	58
	Boys	7	4	11	5	7	12	6	4	10	18	15	33
	Girls	3	6	9	5	2	7	4	5	9	12	13	15
Grade 3	N	10	9	29	10	10	20	10	10	20	30	29	59
	Boys	6	4	10	7	3	10	4	4	8	17	11	28
	Girls	4	5	9	3	7	10	6	6	12	13	18	21
Subtotals (for each school)	N	29	29	58	30	29	59	31	29	60	90	87	177
	Boys	16	13	29	20	16	36	19	13	32	55	42	97
	Girls	13	16	9	10	13	23	12	16	28	35	45	80

NOTES: 'E' = 'experimental'.
'C' = 'control'.
'N' = 'number of students'.

TABLE 2-3
MEAN SCORES ON *WECHSLER INTELLIGENCE SCALE FOR CHILDREN*

		School									Subtotals (for each grade)		
		Urban			Rural			Suburban					
		E	C	E&C	E	C	E&C	E	C	E&C	E	C	E&C
Grade 1	N	9	10	19	10	10	20	11	10	21	30	30	60
	M	104.7	104.8	104.7	101.1	107.4	104.3	119.7	109.3	114.8	109.0	107.1	108.1
	S.D.	6.7	10.5	8.7	14.5	10.6	12.8	9.6	9.8	10.9	13.4	10.1	11.8
Grade 2	N	10	10	20	10	9	19	10	9	19	30	28	58
	M	99.9	107.1	103.5	96.0	109.2	102.3	106.5	113.1	109.6	100.8	109.7	105.1
	S.D.	8.5	18.1	14.2	11.6	13.3	13.8	13.9	12.3	13.3	12.0	14.6	13.9
Grade 3	N	10	9	19	10	10	20	10	10	20	30	29	59
	M	90.1	92.6	91.3	112.3	113.2	112.8	108.3	113.5	110.9	103.6	106.8	105.1
	S.D.	14.2	7.4	11.3	12.3	14.3	13.0	16.0	15.3	15.5	16.9	16.0	16.6
Subtotals (for each school)	N	29	29	58	30	29	59	31	29	60	90	87	177
	M	98.0	101.8	99.8	103.1	110.0	106.5	111.8	111.9	111.9	104.5	107.9	106.2
	S.D.	11.8	14.0	13.1	14.2	12.6	13.8	14.2	12.4	13.3	14.5	13.7	14.1

NOTE: 'E' = 'experimental'.
'C' = 'control'.
'N' = 'number of cases'.
'M' = 'mean'.
'S.D.' = 'estimated population standard deviation'.

to a high in Grade 2 control of 109.7. With only one exception, the mean I.Q. for the control group for any grade-school combination is higher than the mean for the experimental group.

Socioeconomic Status.

A numerical socioeconomic index (SEI) for each child's family was obtained on the basis of the occupation of the father of the child, or the head of the household in the home in which the child was living. A modified form of Warner's seven-place occupational scale (1949, pp. 140-41) was used to obtain the appropriate number. Occupations with the highest socioeconomic status receive a rating of 1, and those with the lowest, a rating of 7. It was possible to find out through school records and school personnel enough information regarding the parents' occupation to rank everyone in the study. However, many of the occupations encountered do not appear on Warner's scale, and some that did were judged to warrant assignment of a different number, at least in this community. The first set of modifications of the Warner ranking, Social Class in America (pp. 140-41), correspond to those of Ennis and Paulus* (page III-6). Further changes were made as follows:

1. Graduate students were ranked 2.
2. A skilled craftsman in his own business was ranked 4.
3. Skilled craftsmen not self-employed were ranked 5.

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*A summary of the six changes and additions is given here:

1. Unemployed people ranked 7.
2. If rank in armed services was unknown officers were ranked 3; enlisted men were ranked 6.
3. College teachers are ranked 1.
4. Dime store clerks ranked 6.
5. Hardware salesmen ranked 4.
6. Electricians (not self-employed) ranked 5.

4. Laboratory technicians were ranked _4_.
5. Office secretaries were ranked _5_.
6. Mailmen and cooks were ranked _5_.
7. Milk deliverymen were ranked _6_.
8. Cashiers in a store or restaurant were ranked _5_.

Some of the most difficult jobs to rank were those administrative and staff positions at the educational institutions. An attempt was made to relate these jobs to comparable positions in business and industry, and rank accordingly.

For the most part the final socioeconomic indices used in this study were based on the evaluation of a single researcher using the modified Warner scale discussed above.* Several occupations for which a number was not obvious were discussed by the entire research group until an agreed-upon number emerged.

Table 2-4 summarizes the socioeconomic index data. It should be noted that a high socioeconomic _index_ (7 is a higher number than 1) is indicative of a low socioeconomic _status_. For purposes of interpretation and discussion we shall speak in terms of socioeconomic _status_ and will consequently reverse the signs of correlations actually obtained between socioeconomic index and other factors. For example, we shall report a positive correlation of .44 between our estimate of socioeconomic _status_ and total score on our conditional logic test, even though the correlation obtained between our socioeconomic _index_ and conditional logic total score

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*In our previous study we found an interrater reliability of .95, so we decided not to use two raters.

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TABLE 2-4
MEAN SOCIOECONOMIC INDICES

		School									Subtotals (for each grade)		
		Urban			Rural			Suburban					
		E	C	E&C	E	C	E&C	E	C	E&C	E	C	E&C
Grade 1	N	9	10	19	10	10	20	11	10	21	30	30	60
	M	4.3	4.4	4.4	4.5	5.2	4.9	1.2	1.6	1.4	3.2	3.7	3.5
	S.D.	1.8	1.8	1.8	2.4	.92	1.8	.40	.84	.67	2.3	2.0	2.2
Grade 2	N	10	10	20	10	9	19	10	9	19	30	28	58
	M	4.4	4.7	4.6	4.4	3.8	4.1	1.9	1.8	1.8	3.6	3.5	3.6
	S.D.	2.0	2.3	2.1	1.4	1.7	1.6	.88	1.3	1.1	1.9	2.2	2.0
Grade 3	N	10	9	19	10	10	20	10	10	20	30	29	59
	M	5.6	5.1	5.4	3.5	3.0	3.3	1.6	2.4	2.0	3.6	3.4	3.5
	S.D.	1.1	1.8	1.5	2.0	1.8	1.9	.97	1.3	1.2	2.1	2.0	2.1
Subtotals (for each school)	N	29	29	58	30	29	59	31	29	60	90	87	177
	M	4.8	4.7	4.8	4.1	4.0	4.1	1.5	1.9	1.7	3.5	3.6	3.5
	S.D.	1.7	2.0	1.8	2.0	1.8	1.8	.81	1.2	1.0	2.1	2.0	2.1

NOTE: A low index indicates high status. See text.
'E' = 'experimental'.
'C' = 'control'.
'N' = 'number of cases'.
'M' = 'mean'.
'S.D.' = 'estimated population standard deviation'.

is a negative .44. We do this in order to avoid confusion in discussion of results.

Our data throws some additional light on the question of the type of neighborhood surrounding the elementary schools in this study. The average socioeconomic status for the rural school is only moderately higher than for the urban school, though interestingly the socioeconomic status increases progressively from grades one to three in the rural school and decreases progressively in the urban school. A standard deviation of 1.8 in each case is indicative of the dispersion in the status of occupations in these neighborhoods. The suburban school has a much higher average socioeconomic status than the other two schools, and less variation of status within the group as evidenced by the standard deviation of 1.2. In fact, the raw data indicate that there are very few occupational rankings lower than three among the children at the suburban school. There is some decrease in socioeconomic status from grades one to three.

Mean SEI is 3.5 for all children. For our urban, rural, and suburban schools, means are 4.8, 4.1, and 1.7, respectively. Although we had considerable representation from all levels, the mean SEI, largely resulting from the one-third influence from the suburban school, probably indicates a slightly higher mean socioeconomic status for our sample than for the country as a whole. A mean of 3.5 is roughly what one would get from a sample evenly split between middle class and lower class, other things being equal.

SUMMARY

Because of our rural, urban, and suburban selection procedures, and because our mean I.Q. and SEI were not far removed from what we would expect for the country as a whole, we feel that our study will be of interest to the country as a whole, but do not want to claim generalizability to children who are different in significant respects.

CHAPTER 3
EDUCATIONAL TREATMENT

Our instruction in logic was carried out using fifteen individually administered audio-tutorial programs with science content. The lessons were installed weekly in a three-sided carrel placed on a table in six of the experimental classrooms. The three classes in the urban school used a single carrel located in a learning center. Each lesson consisted of a set of materials for the child to observe and manipulate, and an audio tape recording. The recording guided the observations and manipulations, presented the logic principles, and posed questions for the child to answer by applying the logic to the situation at hand. In each case a situation was developed which illustrated a scientific principle. After the child had become familiar with the situation, the logic content which the lesson was designed to teach was introduced. Usually the child was then asked questions which required him to apply the logic to the specific situation. Following each such question the correct answer was given together with a brief explanation as to why that answer was correct. Each lesson lasted from fifteen to twenty minutes.

The science content of our lessons was not selected solely because it illustrated the logical principles with which we were concerned. It was intended to develop important understandings in science. The materials are thus the result of the integration of two sets of objectives and two instructional strategies.

RATIONALE FOR AUDIO-TUTORIAL MODE OF INSTRUCTION

There were several reasons for our decision to employ the audio-tutorial mode of instruction. First, we felt that a great deal of our resources should be allocated to the development of instructional strategies and materials. Had we decided to train classroom teachers to carry out the instruction, many of our resources would have been required for the teaching of logic to teachers and the mechanical details of teacher workshops, etc., leaving much less time for the development of teaching strategies and materials.

Second, audio-tutorial lessons can be duplicated and distributed on a wide scale without having to repeat the development phase each time. If teacher-led instruction had been used, the training would have to be repeated for each new class to be taught. Third, the use of individually administered audio-tutorial lessons allows the instruction in logic and science to be included without taking the teacher's time from other subjects. Individual children can be doing the programs while the teacher works on another subject with a small group or other individual children. Moreover, time consuming in-service training was not required of the teachers.

Fourth, the use of audio-tutorial instruction allows each child to manipulate and observe materials in a carefully organized way, integrated with the presentation of principles of logic and science. Such experience is very difficult to achieve for all children in teacher-directed instruction.

THE DEVELOPMENT OF THE MATERIALS

The first step in the development of our materials was the planning of a strategy for teaching the principles of logic. A series of steps leading up to and including the presentation of the principles themselves was prepared, and are listed below:

1. When we tell something about a thing we make a statement about that thing.
2. Statements can be true or they can be not true.

3. We say that statements that are not true are false.

4. There are many ways to find out whether a statement is true or false.

5. One way to find out if a statement is true or false is to look and see.

6. When we look to see if a statement about a thing is true or false we say that we observe that thing.

7. Sometimes we do not have to observe a thing to find out whether a statement about it is true or false. Sometimes we can figure out whether a statement is true or false from other statements that we already know are true. But, we must be very careful when we figure out whether a statement is true or not. It is easy to make mistakes.

8. We cannot always figure out whether a statement is true or false.

9. Sometimes we know enough about a thing to be able to say that if one statement about the thing is true, then another statement about it must also be true.

10. When we say that if one statement is true then another one must also be true, we call what we say an if-then sentence.

11. An if-then sentence has two parts. One part of an if-then sentence says if something. That part is called the if-part. The other part is the part that says then something. It is called the then-part.

12. When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. But we must be careful.

13. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false.

14. When we have a true if-then sentence, we can tell that the if-part is false by finding out that the then-part is false. But again, we must be careful.

15. If all we know is that the then-part is true, we cannot figure out whether the if-part is true or false.

16. When the then-part of one true if-then sentence is the if-part of another one, we can figure out that the then-part of the second one is true if we know that the if-part of the first is true.

The second step was the development of a parallel strategy for the science content of our lessons. This strategy was built around the notion of conservation of energy in energy transformations. The following steps represent our strategy for teaching the science content:

1. There are different kinds of energy.
    a. Things that make other things warmer give off heat energy.
    b. Things that make light give off light energy.
    c. Things that are moving have kinetic energy.

2. Things that have energy can give energy to other things.
    a. One thing that has kinetic energy can give some of its kinetic energy to another thing.
    b. One thing can give some of its heat energy to another thing.

3. Some kinds of energy can be stored and used later. Squeezed springs have energy stored in them--spring energy.

4. One kind of energy can be changed into a different kind of energy. Spring energy can be changed into kinetic energy.

5. Another kind of stored energy is gravity energy.
    a. If you raise a thing up and just let it go, it will fall toward the earth because force of gravity pushes it.
    b. Everything on earth or near it is pulled toward earth by force of gravity.
    c. Things which are raised up have stored energy (stored gravity energy).
    d. Gravity energy can be changed to kinetic energy.

6. Another kind of energy is electrical energy.
    a. Kinetic energy can be changed into another kind of energy called electrical energy.
    b. Electrical energy can be changed to light energy, heat energy, and kinetic energy.

7. Kinetic energy can be changed into heat energy by rubbing two things together, causing friction.

8. Scientists believe that energy can come only from other kinds of energy.

9. Scientists ask many questions. Knowing about energy helps them ask questions. When they see something that has or gives off energy, they ask, "Where did that thing get its energy? What kind of energy did this energy come from?" We can ask these kinds of questions, too.

10. Gravity energy stored in water changes into kinetic energy as the water falls. The falling water gives some of its kinetic energy to the water wheels in big electrical generators. The kinetic energy is changed into electrical energy in the generators. The electrical energy is changed into heat, light, and kinetic energy in our homes.

11. A complete circuit is a path which electricity can go around and come back to where it started. A light bulb must be in a complete circuit in order to light up. Electrical energy changes into light energy in the wire inside a light bulb.

12. When a battery is connected in a complete circuit, the chemicals in the battery change into different chemicals. When they change they give off electrical energy.

13. Everything is made of chemicals. The chemicals in many things can change and give off energy.

14. The chemicals in wood change when the wood burns and give off heat and light energy. The chemicals in wood have a kind of stored energy in them. We call the kind of energy that those chemicals have chemical energy. When wood burns, the chemical energy stored in the chemicals in the wood changes into heat and light energy.

15. The trees and other plants get energy to grow from sunlight. They use that light energy to make the chemicals wood is made of.

The next phase in the development of our instructional program was the selection of the particular materials to use for each lesson. The materials had to be appropriate for illustrating both the logic and science principles which were next in each sequence. When appropriate materials had been selected and built or obtained, a script was prepared for the lesson. The script was then recorded and the programs tried out with from three to five children. These children were carefully observed using behavioral check lists and were questioned about difficulties they might have encountered. Revisions were then made and the revised program tried with additional children. This process was repeated as many times as our schedule would allow. The earlier programs were revised up to five times while some of the later ones were completely revised only once.

THE INSTRUCTIONAL MATERIALS

The complete script of one of the programs is included in Appendix A as are summaries of the contents and materials of each of fifteen programs which were developed. Several features of the instructional materials should be noted.

1. The programs ask the child to make decisions about the truth of statements presented to him. It was found that asking the child to think of his answer often failed to result in his reaching a decision. For this reason, a box with the words true and false cut out and wired so that the words lighted up when the respective levers were pressed was placed in the carrel. It was found that children almost never failed to reach a decision when directed to indicate their answer by pressing a lever. The device also allowed an observer to monitor the child's responses.

2. The language used in the lessons was just that used in the strategies included on pages 29-32. Since the logic principles were presented in the context of true if-then sentences, they deal with assertions of the truth of the parts of the sentence. No attempt was made to deal with valid arguments with dubious conditional premises. Rather, the application of the principles to true conditional statements was stressed.

TABLE 3-1
PROPORTION OF CHILDREN WHO GAVE CORRECT ANSWERS TO QUESTIONS ON THE INFORMAL TEST IN PROGRAM SEVEN

Item No.	Proportion of Children Getting Item Correct			Item Content
	Grade 1 N = 26*	Grade 2 N = 30	Grade 3 N = 21*	
1	.73	.90	1.0	Identification of letters and shapes used in programs.
2	.73	.90	1.0	
3	.92	.93	1.0	
4	.92	.93	.95	
5	.96	.93	.95	
6	.85	.93	1.0	Identification of words used in programs.
7	.69	.97	1.0	
8	.69	.97	.95	
9	.69	.97	1.0	
10	.92	.97	.91	True** - familiar content.
11	.92	.97	1.0	Maybe** - familiar content.
12	.89	.73	.72	Kinetic energy.
13	.76	.83	.86	True - kinetic energy.
14	.57	.73	.81	Maybe - kinetic energy.
15	.31	.47	.43	True (negative statement) - kinetic energy.
16	.19	.23	.38	Light energy.
17	.46	.60	.76	True - kinetic--electrical energy.
18	.35	.60	.67	True - electrical--light energy
19	.15	.30	.43	False** - force of gravity
20	.89	.73	.91	Identification of stored energy.
21	.27	.30	.52	
22	.61	.67	.72	
23	.27	.33	.38	Making up an appropriate if-then sentence with picture cards.

*Some of the children did not return their answer sheets.

**Several of the questions required the children to indicate whether a statement was true, false, or whether insufficient information was available to judge (maybe). The correct answer is indicated for such items.

3. It was hoped that our materials might ultimately be integrated into a larger program using audio-tutorial instruction. For this reason the science content for our lessons was selected so that it supplemented that of the Cornell Elementary Science Project. That project uses audio-tutorial instruction.

4. An effort was made to include concrete materials in each lesson. Where this was difficult or dangerous, film loops or pictures were used instead.

Program seven contained no new content. It was designed as an informal test to find out whether the children were following directions carefully, and also to provide some indication of whether or not they had mastered the content of the first six programs. For this program answer sheets were provided in the carrel. Table 3-1 contains a summary of the results from that test program. The data indicate that most of the children were quite able to follow the directions, that most had an understanding of the notion of a true statement and the notion of a statement whose truth status is in doubt, that there was a large variation in the degree to which the children understood the various types of energy, and that the idea of making up an if-then sentence and representing it with pictures was not very well understood.

The results of the test were taken into account in the building in of review in later programs.

THE ADMINISTRATION OF THE INSTRUCTION

Carrels were placed in six of the nine experimental classrooms. Since the experimental and control subjects were all drawn from the same classrooms in the urban school, a carrel for the experimental subjects in that school was placed in the learning center. A carrel supervisor from the project installed the new programs, usually one each week. The teachers were allowed to schedule the children's visits to the carrels at their own convenience. They were asked only to make sure that all of the experimental subjects went through the programs and to report malfunctions of equipment or other problems to the carrel supervisor as soon as possible. Project staff oriented the experimental subjects to the use of the carrel and the tape recorder. The booth supervisor kept close watch over the first subjects to go through the programs, particularly in the urban school where the children had to go to the learning center. After the first program, the booth supervisor visited each classroom two or three times a week to check the materials in the carrels and deal with any problems which had come up. Problems with rewinding of the tapes with the first program or two were overcome by revision of the instructions and assistance from the supervisor. Several pieces of equipment designed by project staff for use in the lessons were found to be subject to frequent breakdown. Equipment for the later programs was simplified and made less prone to breakdown.

The booth supervisor kept in close contact with teachers and principals in order to benefit from any reactions to the materials that they might have noted. Three children became quite anxious about their performance in the carrels, even though they were not being observed or graded. The booth supervisor worked individually with those children and the problems were largely alleviated.

The reactions of teachers and children to the instruction were generally quite positive and enthusiastic with the exceptions noted above. Some children did express frustration about the mechanical breakdowns mentioned earlier. Most teachers expressed regret when the carrels were removed from their rooms at the conclusion of our instruction. Other important comments from teachers indicated that the children responded very well to being given the responsibility of going to the carrel and operating the equipment by themselves. Several teachers felt that the children's abilities to follow directions were improving. Of course it is difficult to assess the validity of such impressions, but in general the instructional program did make a favorable impression.

SUGGESTIONS FOR FUTURE DEVELOPMENT

Our project staff is optimistic about the possibilities for audio-tutorial instruction. However, several important lessons were learned in the present study. First of all, very extensive tryout and revision is essential. The use of small numbers of children who are very carefully observed is a very efficient way of finding major problems. Careful observation and recording of errors made by children during the lessons should be carried out. The children's own reactions to the materials are often very helpful.

The very intensive use made of the materials required that they be extremely durable. We had frequent problems with some of the materials we designed and built ourselves. We feel that such materials are often very desirable, but provision must be made for adequate technical support in the production of such materials. Rigid quality control should be enforced.

Time should be planned so that the entire instructional package can be tried out on a small group of children under standard conditions before large scale tryout and extensive testing are carried out. Error rate data should be collected on at least part of such a group.

CHAPTER 4
THE SMITH-STURGEON CONDITIONAL REASONING TEST

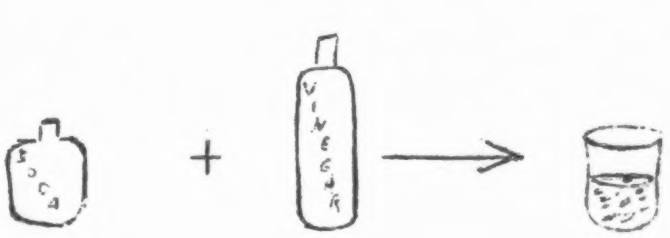
The special problems of testing young children led us to develop a test which presents each child with concrete situations about which he is asked to reason. This decision makes it more difficult to compare the results of our current study with those of our previous study of logic in adolescence. However, we felt that a more valid assessment of children's logical abilities was worth sacrificing some comparability. This was particularly true since part of our goal was assessing the effectiveness of our logic instruction.

RATIONALE FOR THE FORM OF THE TEST

The testing of primary children imposes many problems which either don't exist or are less critical with older children or adults. An obvious problem is that of motivation. The use of interesting concrete situations was expected to improve the motivation of the subjects to put serious thought into the questions. The individual interview technique and the requiring of justifications allowed the tester to make a reasonable judgment as to whether or not the child was seriously attempting to answer the questions.

Another problem is the lack of reading ability of primary children. This problem is more than an inconvenience which simply requires a person to read the questions aloud. Whereas a written item is easily available to a reader for frequent reference, an item read out loud is available only once or twice, and then only when the tester decides to read it or when the subject is aggressive enough to ask for a rereading. This places a greater load on the subject's memory. Thus, a likely source of error in the child's answer is a forgotten premise. In addition to having the major premises of the arguments demonstrated in a concrete situation, picture symbols were used to aid the child in remembering them. For example, the major premise in the test item described above was, 'If this white powder is baking soda, then it will bubble when vinegar is added to it.' The following pictures were placed on a magnet board during that part of the test.

FIGURE 4-1

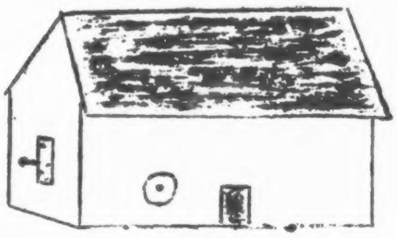


As pointed out in Chapter 1, the affirmation of the then-part when the if-part of the conditional was the case was required as evidence of understanding and recall of the major premise for each argument in the test. If a subject failed to make that affirmation, it was assumed that he hadn't understood or had forgotten what had been said and shown, and the teaching of the major premise was repeated. It was also hoped that the use of concrete and pictorial materials would reduce the effects of purely verbal skills on children's performance on the test.

TESTING MATERIALS AND PROCEDURES

Since the entire script for the test and the ground rules for the interviewing and scoring are included in the Appendix, only the main features of the test will be described here. The test was presented in two parts, each part using a different set of materials. One part, hereafter referred to as the house part, involved questions about a model house. The other, hereafter referred to as the chemicals part, involved questions about chemical reactions with safe, household chemicals. The model house had two handles (knife switches) and a push button switch on the outside, and a doorbell and a light inside. The light was visible through a small window when the light was on and the window open.

FIGURE 4-2



The following conditional statements represent the information about the house from which the children were asked to reason on the house part:

1. If the big handle is up, then the bell works.
2. If the light is on, then the big handle is up.
3. If the bell does not work, then the big handle is down.
4. If the big handle is down, then the light is not on.

At the beginning of the house part the child was shown that there were two handles, but he was not allowed to find out about the function of the small one. He was allowed to find out that the bell does not always ring. Thus, the possibility that the small handle's being up also implied that the bell would work was left open as was the possibility that it would work only when the large handle was up. The child was shown and assured only that the large handle's being up was a sufficient condition for the bell to work.

Specification of exactly what the child was told and not told about the situation is quite important since the difficulty of the fallacy questions seems closely related to the child's awareness of alternative conditions which might imply the same conclusion. The child's knowledge of the existence of the second switch provides one specific alternative that he might consider.

The following conditional statements represent the information from which the children were asked to reason on the chemicals part:

5. If a white powder is soda, then it bubbles when vinegar is added.
6. If a white powder is sugar, then vinegar added to it turns white.
7. If a liquid is vinegar, then it makes soda bubble.
8. If a liquid makes soda bubble, then it turns litmus paper red.

At the beginning of the chemicals part, the children were shown several different reactions with vinegar and unidentified white powders. Thus, they had all had experience with white powders that bubbled when vinegar was added and with white powders that turned vinegar milky. The possibility that several different white powders would bubble when added to vinegar was left open. The same was true for powders that turn vinegar milky.

A standard procedure was used in presenting each question. The first step was to teach or review the major premise(s) using the materials and the appropriate pictures. When the child had demonstrated that he recalled the major premise(s) he was asked to suppose (for the suppositional questions), or was shown (for the factual questions), that one part of the conditional statement was true (or false). He was then asked about the truth status of the other part. In each case the child was offered three choices. One choice was the affirmation of the part of the conditional statement under consideration, another was the denial of that part, and the third was neither. For example, in asking about the position of the big handle on the model house, the tester asked, "Would you say that the big handle is up, is not up, or would you say that maybe it is and maybe it is not?" Following the child's response, the tester asked for a justification of it. An appropriate justification was required for credit to be given for a correct answer.

The questions were always asked in pairs made of the suppositional form and the factual form. In each case the suppositional form was asked first. The answer and the justification were obtained for the "supposed" case and then the materials were arranged so that the minor premise of the argument could be affirmed on the basis of observation. The question was then repeated and a justification sought.

THE STRUCTURE OF THE TEST

The test consisted of 24 items in all. Six items applied to each of the four principles. Each group of six items is referred to as an item group. Three of the items in each item group were the suppositional form of the questions asked of the children while the other three were the factual forms. Some of the items for each principle were from the house part and the rest from the chemicals part. Table 4-1 provides a description of each item.

TABLE 4-1
DESCRIPTION OF ITEMS ON THE SMITH-STURGEON CONDITIONAL REASONING TEST

Principle	Logical Form of Items[1]	Alternative Answers	Content of Items			
			Item	Part of Test	Form	Major Premise[2]
Inversion	If p, then q not p ∴ ?	q not q maybe	5	Chemicals	Suppositional	5
			6	Chemicals	Factual	5
			11	Chemicals	Suppositional	6
			12	Chemicals	Factual	6
			17	House	Suppositional	1
			18	House	Factual	1
Conversion	If p, then q q ∴ ?	p not p maybe	1	Chemicals	Suppositional	5
			2	Chemicals	Factual	5
			7	Chemicals	Suppositional	6
			8	Chemicals	Factual	6
			15	House	Suppositional	1
			16	House	Factual	1
Contraposition	If p, then q q ∴ ?	p not p maybe	3	Chemicals	Suppositional	5
			4	Chemicals	Factual	5
			9	Chemicals	Suppositional	6
			10	Chemicals	Factual	6
			19	House	Suppositional	1
			20	House	Factual	1
Transitivity	If r, then p If p, then q r ∴ ?	q not q maybe	13	Chemicals	Suppositional	7 & 8
			14	Chemicals	Factual	7 & 8
			21	House	Suppositional	1 & 2
			22	House	Factual	1 & 2
			23	House	Suppositional	3 & 4
			24	House	Factual	3 & 4

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[1] The three alternatives presented to the child are given and the correct one is underlined.

[2] The numbers refer to the conditional statements listed earlier in this chapter in the section, "Testing Materials and Procedures".

The structure of the test provides several subscores as well as the total score. Subscores can be obtained for each of the four principles, for the fallacy principles and validity principles, for each of the two forms of the questions (the suppositional and the factual), and for each of the two parts of the test (the house part and the chemicals part). Although the differences between the factual and suppositional scores are of interest, the fact that each suppositional-factual pair of items dealt with the same situation and was presented together in sequence probably means that the differences were not the same as those which might otherwise have occurred. The interpretation of these scores is discussed in Chapter 5. The house and chemicals parts of the test were designed to measure the same things so those scores are of interest in considering the validity of the test. They may also shed light on some factors which influence the difficulty of test items within item groups.

CRITERIA FOR MASTERY

As pointed out in Chapter 1, two operational definitions of mastery were prepared for the purpose of formalizing our judgments about mastery:

1. If x is given the Smith-Sturgeon Test of Conditional Reasoning under standard conditions; then if x gets a score of five or six (out of six) on the items assigned to a given principle, x has probably mastered that principle.

2. If x is given the Smith-Sturgeon Test of Conditional Reasoning under standard conditions; then if x gets a score of three or below (out of six) on the items assigned to a given principle, x has probably not mastered that principle.

Applying these criteria, we judge probable mastery for a score of five or six, withhold judgment for a score of four, and judge probable non-mastery for a score of three or below. In addition to applying our judgment to the selection of the number right required for mastery, we also judged the reasons given by each child to justify his answers. For example, test item 18 required the child to reason from the conditional statement, "If the big handle is up, then the bell can work." After observing that the bell could work at that time, he was asked, "Would you say that the big handle is up, is not up, or would you say that maybe it is and maybe it is not?" The correct choice was that maybe it was up and maybe it was not up, because insufficient information had been presented for determining whether or not the handle's being up was a necessary condition for the bell to work. However, that choice alone was not sufficient. A child giving that response was then asked, "Why can't you tell?" A justification was required to the effect that it had not been established that the big handle must be up in order for the bell to work. Typical responses were, "The big handle might not be the only way to make the bell work," or, "There may be other ways that the bell can work." The kinds of justifications judged acceptable for each item are listed on the sample scoring sheets in the Appendix.

There are several reasons for requiring justifications of the responses:

1. We wanted to reduce the number of items mistakenly judged correct because of wild guessing.
2. We wanted to avoid confusing a well reasoned "maybe" answer from a simple answer of "I don't know what alternative is appropriate."
3. We wanted to catch and dispel any tendencies the children might have to suspect that we were going to trick them by changing the house, etc.
4. We wanted to avoid giving credit to children who

②

> had given the right answer for some other inappropriate reason.

We feel that the application of these criteria represents a rather strict judgment about the reasoning abilities displayed by the children in our test.

ANALYSIS OF THE TEST

Reliability.

Since interpretations are made of subscores of the test, the reliability of each such subscore as well as that of the total score is important. Kuder-Richardson coefficients of internal consistency were calculated for each subscore and the total score for each grade level of children included in our study. The results are shown in Table 4-2. Accompanying these coefficients are the means and standard deviations of the scores from which the coefficients were calculated. The variability of the contraposition scores is low, particularly in the third grade group, because so many children achieved the maximum score of six. This resulted in the lower coefficients for that subscore at the second and third grade levels. For the rest of the principle subscores, however, relatively high coefficients were obtained, despite the small number of items.

Validity.

Several approaches to the validity of our test seem appropriate: Examining the test items and the procedures used to develop them to see if they represent the subject matter they are supposed to represent; determining whether the internal features of our test, as revealed by our empirical results, make sense in light of our conception of children's logical abilities; determining the test's correlations with familiar measures and seeing if

TABLE 4-2
KUDER-RICHARDSON COEFFICIENTS OF INTERNAL CONSISTENCY FOR THE SMITH-STURGEON CONDITIONAL REASONING TEST
(Control Group Only)

Type of Score	Max. Poss. Score (No. of Items)	Grade 1, N=30			Grade 2, N=28			Grade 3, N=29			All Grades, N=87		
		Mean	S.D.	r_{tt}	Mean	S.D.	r_{tt}	Mean	S.D.	r_{tt}	Mean	S.D.	r_{tt}
Total	24	10.7	5.1	.81	14.3	5.5	.85	14.1	5.4	.83	13.0	5.5	.84
Inversion	6	2.6	2.1	.84	3.5	2.3	.89	3.0	2.3	.86	3.0	2.3	.84
Conversion	6	1.7	1.6	.74	2.5	2.0	.85	2.0	1.9	.83	2.0	1.9	.82
Contraposition	6	3.9	1.8	.76	4.9	1.0	.43	5.1	1.0	.07	4.6	1.4	.66
Transitivity	6	2.6	1.8	.76	3.4	1.9	.79	4.0	2.0	.83	3.3	2.0	.80
Fallacy	12	2.2	3.4	.89	2.4	4.1	.95	2.6	3.8	.90	2.4	3.8	.91
Validity	12	2.6	3.0	.79	2.0	2.5	.75	2.2	2.5	.85	2.3	2.9	.80
Suppositional	12	2.5	3.2	.84	2.4	3.2	.85	2.5	2.8	.75	2.5	3.2	.83
Factual	12	2.3	2.5	.70	2.0	2.4	.73	2.3	2.7	.76	2.2	2.6	.73
House	10	2.0	1.92	.51	1.9	2.44	.75	2.0	2.28	.68	2.0	2.32	.69
Chemicals	14	2.8	4.0	.91	2.5	3.7	.90	2.8	3.9	.89	2.7	3.9	.91

NOTE: 'S.D.' = 'estimated population standard deviation'.
'rtt' = 'reliability of the test'.

these relationships make sense; and seeing how much sense one can make out of the investigations which depend upon the test.

Content validity. The test scripts (see Appendix B) provide evidence about the validity of our test. For each test item the child is presented with a conditional relationship which is described verbally and illustrated with the materials themselves. He is then asked to suppose (in the suppositional items) or is shown (in the factual items) the truth status of one of the conditions of the relationship, and asked to state what conclusion he can make, if any, about the truth status of the other condition. Further, he is asked to justify his stated conclusion or why no conclusion can be made. The correct answers to these questions are implied by the principles we are testing. It seems to us that consistent correct answers to these questions imply an important degree of understanding of the principles of logic we were testing for. Our judgment of what constitutes consistency in these cases is reflected in our definitions of mastery presented in the section of this chapter on "Criteria for Mastery". We cannot prove this assertion, but leave it to the intelligent judgment of informed, interested people.

Although we are interested in children's abilities to reason from conditional statements with many different kinds of content, we have chosen to concentrate on those with somewhat restricted types of content. The conditional statements from which children were asked to reason in our test were about concrete materials which the children were shown. The statements were consistent with the information the children were given about those materials. Thus, the basic meanings of the conditional statements used in the test were not contrary to the beliefs of the children, although they could have made additional unwarranted assumptions about the materials. It is important in interpreting our test results not to generalize our findings to children's abilities to reason from other kinds of conditionals unless additional evidence has been found which warrants such generalizing.

We used conditional relationships in two sets of materials. This is not intended to be a sample which would allow us to generalize our findings to all sets of materials that might be chosen. It is not likely that our materials are the most difficult nor the simplest about which to reason. We, therefore, assumed that successful performance with the materials selected for our test implies ability to perform successfully in a nontrivial number of other situations. Since we have used two quite different sets of materials, a comparison of children's performance with them will provide some evidence about which aspects of our results are likely to vary from one set of materials to another. This comparison is discussed in the next section of this chapter.

Construct validity. This type of validity deals with the extent to which the test results make sense in the context of our conception of children's logical abilities.

As described in Chapter 1, we conceive of ability in conditional logic as a set of abilities rather than a single one which is either mastered or not mastered. In the previous section of this chapter, it was pointed out that our test presented the children with two different types of situations from which to reason. An important aspect of validity is whether or not our test allows us to predict performance in other situations. Since we have not investigated other situations we cannot answer that question directly. However, by comparing the two situations we selected we can make some estimate of what, if anything, we might be able to predict about other similar situations.

A technique for determining the validity of tests of traits or abilities was suggested by Campbell and Fiske (1959). This technique can be applied to tests which involve measuring two or more traits with two or more methods. Our test fits this pattern since we attempted to measure ability to apply four different principles and provided two different situations for measuring each. The technique involves treating each principle-situation (trait-method) combination as a separate test and computing all intercorrelations. If the traits as defined are behaviorally distinct, if the test actually measures each trait, and if the trait is generalizable from one situation to another, then the correlations between the same traits measured by different methods (monotrait, heteromethod) should be higher than those between different traits measured by the same method (heterotrait, monomethod) and also higher than those between different traits measured by different methods (heterotrait, heteromethod). Table 4-3 shows the results of the analysis of the control groups tests. The four monotrait, heteromethod scores are underlined. As can be seen the expected pattern was not generally obtained. The only principle (trait) which clearly fits the pattern is the inversion principle. The two measurments of the contraposition principle appear virtually unrelated. These results indicate that we probably cannot expect to predict with much accuracy which individuals will demonstrate ability to apply the contraposition principle in new situations.

Failure of the data to conform more completely to the expected pattern implies the failure to meet all of the conditions listed above; that is, the problem may lie with the definition of the traits themselves,

TABLE 4-3
MULTITRAIT-MULTIMETHOD CORRELATION MATRIX FOR
FOUR PRINCIPLES (TRAITS) AND TWO SETS OF MATERIALS (METHODS)

Test	Principle (Trait)	House Part (Method 1)				Chemicals Part (Method 2)			
		Principle (Trait)				Principle (Trait)			
		Inversion	Conversion	Contraposition	Transitivity	Inversion	Conversion	Contraposition	Transitivity
House Part	Inversion								
	Conversion	.34							
	Contraposition	.04	.21						
	Transitivity	-.13	.17	.35					
Chemicals Part	Inversion	.44	.21	.17	.15				
	Conversion	.35	.24	.10	.24	.73			
	Contraposition	.20	.08	.05	.26	.20	.26		
	Transitivity	.18	.21	.26	.29	.27	.22	.25	

The underlined correlations are those between measurements of the same principle in different situations (monotrait, heteromethod), mean = 0.26. Those enclosed in solid triangles are between measurements of different principles in the same situation (heterotrait, monomethod), mean = 0.27. Those enclosed in broken triangles are between measurements of different principles in different situations (heterotrait, heteromethod), mean = 0.20.

the test procedures used, the fact that possession of the trait in one situation is unrelated to its possession in another, or to some combination of these factors. The analysis itself cannot tell us which factor or factors are responsible. Aspects of the test and the testing procedures probably account for part of the problem. The two parts of the test (the house part and the chemicals part) were administered to individual children at different times and in many cases by different testers. Although considerable effort was made to administer the test in a standard way, there were probably some variations among testers. We have data which suggest that there were some variations among testers although the differences among the children tested by each tester make such comparisons hard to interpret even when the scores are statistically adjusted to compensate for these differences. Table 4-4 shows the data from a comparison of our testers. Differences among testers reached significance at the 5% level on the inversion principle on both parts of the test. Another problem area involves the procedures used with the transitivity items on the chemicals part of the test. These items were added to the test at a late stage in the test's development and through an oversight pictorial representations of the premises were not used. These were the only items for which such representations were not used. Since these premises were particularly complex, this difference in procedures may, unfortunately, have been quite critical.

Another interpretation of the results of the multitrait-multimethod analysis is that the logical performance of children is highly dependent on the content of the argument. The child's knowledge of the materials, the complexity of the situation or other content specific factors may play a large roll in determining logical performance. We suspect that one of the

TABLE 4-4
ANALYSIS OF COVARIANCE:* COMPARISON OF SCORES OF CHILDREN TESTED BY EACH OF THE FIVE TESTERS

Description of Score		Adjusted Means* For Children Tested By Each Tester					F Statistic
		Tester					
Part of Test	Principle	#1	#2	#3	#4	#5	
Chemicals	Inversion	3.7	2.1	2.3	3.1	2.8	4.24**
	Conversion	2.1	1.4	1.8	2.3	2.3	2.53
	Contraposition	4.7	4.3	4.4	4.6	3.9	1.60
	Transitivity	2.9	3.9	3.8	3.3	2.9	2.46
	TOTAL***	13.4	11.7	12.3	13.4	11.9	1.33
House	Inversion	2.9	2.3	2.3	3.4	3.3	2.49**
	Conversion	1.9	1.7	2.4	1.8	2.2	.89
	Contraposition	4.6	4.2	4.0	4.4	4.7	1.57
	Transitivity	3.5	3.1	3.9	3.2	3.5	.96
	TOTAL***	12.8	11.2	12.7	13.0	13.7	1.86

*I.Q., SEI, and age are covariates.
**Indicates significance at the 5% level.
***Principle and Total adjusted means are computed separately and are not necessarily additive.

Level of Significance
For F Statistic:

df (4,200)	2.41 at 5% level
df (4,150)	2.43 at 5% level

reasons the items from the house part of the test were in general more difficult than those for the same principle from the chemicals part was the previous experience children have had with electric switches. We found during the testing that some of the children even had doorbells with knife switches included in the circuits in their homes. The fact that the doorbell in our model house could be made functional by either of two switches probably resulted in many children making inappropriate assumptions about the house. The very low discrimination indices (shown in Table 4-5) obtained for the fallacy items on the house part of the test support this interpretation.

Since our conception of children's logical abilities implies certain relationships among the principles, the intercorrelations of the principles also yield evidence about the internal consistency of our results. The validity principles (contraposition and transitivity) are logically related since they both provide grounds for asserting the necessity of drawing a conclusion. The fallacy principles (inversion and conversion) are logically related since they both specify conditions under which conclusions do not follow necessarily. If these distinctions are valid psychologically as well as logically, then the correlations between the pairs of logically related principles should be considerably higher than those between the logically unrelated (or less closely related) principles. Table 4-7 (shown on page 50) indicates that this is the case for the control group scores.

The patterns of difficulty levels of the principles is another source of evidence about the internal consistency of our test results. In Table 4-6 the principles are ranked in order of difficulty based on the mean of the difficulty indices for the appropriate items on each part of the test.

TABLE 4-5
DISCRIMINATION INDICES* FOR ITEMS ON THE SMITH-STURGEON CONDITIONAL REASONING TEST
(Control Group, N = 87)

Item No.	Principle	Form	Part of Test	Discrimination Index
5	Inversion	Suppositional	Chemicals	.75
6	Inversion	Factual	Chemicals	.54
11	Inversion	Suppositional	Chemicals	.63
12	Inversion	Factual	Chemicals	.71
17	Inversion	Suppositional	House	.50
18	Inversion	Factual	House	.33
1	Conversion	Suppositional	Chemicals	.67
2	Conversion	Factual	Chemicals	.79
7	Conversion	Suppositional	Chemicals	.83
8	Conversion	Factual	Chemicals	.67
15	Conversion	Suppositional	House	.21
16	Conversion	Factual	House	.21
3	Contraposition	Suppositional	Chemicals	.46
4	Contraposition	Factual	Chemicals	.29
9	Contraposition	Suppositional	Chemicals	.25
10	Contraposition	Factual	Chemicals	.21
19	Contraposition	Supposition	House	.63
20	Contraposition	Factual	House	.50
13	Transitivity	Suppositional	Chemicals	.54
14	Transitivity	Factual	Chemicals	.63
21	Transitivity	Suppositional	House	.88
22	Transitivity	Factual	House	.71
23	Transitivity	Suppositional	House	.63
24	Transitivity	Factual	House	.42

*Discrimination indices were computed from the formula $D.I. = \frac{A-B}{C}$, where A = number of the top 27% (based on total test score) who got the item correct, and B = number of the bottom 27% (based on total test score) who got the item correct.

TABLE 4-6
RELATIVE DIFFICULTIES OF ITEMS FOR EACH PRINCIPLE FOR EACH PART OF THE TEST

Rank	Chemicals Part			House Part		
	Principle	Mean Difficulty Index	Number of Items	Principle	Mean Difficulty Index	Number of Items
1	Contraposition	.86	4	Transitivity	.67	4
2	Inversion	.57	4	Contraposition	.58	2
3	Conversion	.49	4	Inversion	.41	2
4	Transitivity	.33	2	Conversion	.07	2

TABLE 4-7
PRODUCT MOMENT CORRELATIONS AMONG PRINCIPLE SCORES
FOR ALL CONTROL GROUP CHILDREN

	Fallacy Principles		Validity Principles	
	Inversion	Conversion	Contraposition	Transitivity
Inversion	---	.71*	.28	.18
Conversion	---	---	.30	.31
Contraposition	---	---	---	.48**
Transitivity	---	---	---	---

There is one discrepancy in the two patterns. The transitivity items were the most difficult ones in the chemicals part of the test whereas they were the easiest in the house part. This may have resulted from the differences in procedures, mentioned above, used on the transitivity items on the chemicals part. The patterns of difficulty on the other three principles are the same for both parts of the test. Thus, these data do provide some evidence for internal consistency of our test.

Further evidence concerning the validity of the test is provided by considering the relationships between test scores and familiar variables. Because deductive logic is a basic component of many intellectual tasks, we expected a relatively high correlation between test scores and I.Q. Since logic is also verbal in nature, we expected a particularly high correlation of test scores with the verbal subscores of the WISC. The same factors suggest at least some relationship between test scores and SES since the value placed on intellectual achievement, and the development of verbal skills, seems to be related to social class. The results of our earlier study of logic led us to expect a substantial correlation of test scores with chronological age (when all three grades are considered together), but not with sex.

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*The correlation between the two fallacy principles.
**The correlation between the two validity principles.

We obtained correlations with these familiar variables that were basically in agreement with our expectations. The correlations between test scores and these variables for the control group children are shown in Table 4-8.

TABLE 4-8
CORRELATION OF CONTROL GROUP TEST SCORES
WITH I.Q., SES, CHRONOLOGICAL AGE AND SEX

Grade	N	I.Q.		SES	CA	Sex*
		Full	Verbal			
1	30	.37	.50	.39	.16	-.21
2	28	.59	.64	.48	-.13	-.21
3	29	.58	.62	.46	-.19	.00
1, 2 & 3	87	.51	.57	.44	.19	-.13

There were relatively high correlations between test scores and I.Q., and between test scores and SES. As expected, the correlation with the verbal subscore of the WISC was somewhat higher than that with the full I.Q. There was a correlation with age (with grades combined) although it was not as high as those obtained in our earlier study with older children. Alternative interpretations of this result are discussed in Chapter 5. The correlation with sex favors the boys although it is not very high. The inconsistency across grades suggests that the correlations for grades one and two are chance occurrences.

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*Girls were assigned 2 and boys 1. Thus, a negative correlation indicates that the boys in that group tended to get higher scores than the girls.

The principle intercorrelation and difficulty data, and the correlations with familiar variables, provide evidence for the psychological validity of the principles as defined in this study. It thus seems that the failure of our results to conform more completely to the expected pattern in the multitrait-multimethod analysis is largely due to the dependence of performance on the specific content of the arguments with which the children are asked to reason and/or inadequacies of the test. Although further investigation will be required to determine the magnitudes of the contributions of each of these factors, our analysis indicates that both are probably involved.

CHAPTER 5
RESULTS AND DISCUSSION

Our data indicate that among children not specially instructed in logic, there is a great deal of variation in ability to handle conditional logic, some being very good and some being rather weak; that they are better at determining validity than invalidity; that children under 11-12 do have suppositional ability, although they appear somewhat better at dealing with factual than suppositional premises; that there is little or no relation at ages 6-9 between logic ability and sex; that there is some relation at ages 6-9 between ability in conditional logic and chronological age, though the relationship is a weak one; that there is a stronger relationship between socioeconomic status and conditional logic ability; that there is still stronger relationship between verbal intelligence and conditional logic ability; and finally, that there does not seem to be much relationship between dwelling areas as we categorized them (urban, rural, and suburban) and conditional logic ability, when one compensates for I.Q., socioeconomic status, and age differences. Our data also indicate that our teaching materials did not help the children who used them, although there already is considerable knowledge of conditional logic among 6-9 year olds. In this chapter we shall summarize and discuss the data that lead us to these conclusions.

Throughout the discussion of the results it should be remembered that this was not a longitudinal developmental study. No children were followed through all three grades. Ours is a snapshot study, our interpretation of which makes the assumption that the older groups are essentially what the younger groups will be like when they are older.

VARIATION

In presenting our developmental results we shall report the experimental group results separately, since something happened to the experimental groups that automatically disqualifies them from straightforward designation by the word 'typical': they received instruction in logic. These results do have some corroborative force, we believe, because the instruction we provided apparently had no effect on the experimental groups. However, our discussion will focus on the control group. Unless we specify otherwise we shall be referring to the control group in discussing the developmental question.

Table 5-1 (the mastery table) shows the number of students at the three grade levels who demonstrated mastery and non-mastery on each of the four principles for which we tested: inversion, conversion, contraposition, and transitivity. Table 5-2 (the means table) shows the mean scores and standard deviations for the various groups of students on the four principles, on the suppositional and factual aspects, and on the total test. Both of these tables give a picture of considerable variation from principle to principle. About one-third to one-fourth of our students have mastered inversion, one-twentieth conversion, one-half contraposition, and one-third to one-fourth transitivity.* The contrast between conversion and contraposition is particularly striking: 6% mastery compared with 55% mastery. The comparable mean scores are 2.0 and 4.6 on 6-item tests.

The mastery table shows, in addition, a wide range among individual

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*We are deliberately vague through the use of the phrase "one-third to one-fourth", since there is some discrepancy between experimental and control groups, perhaps due to chance.

TABLE 5-1
MASTERY OF FOUR BASIC PRINCIPLES OF CONDITIONAL LOGIC

		Inversion				Conversion				Contraposition				Transitivity			
		Mastery	?	Non-Mastery		Mastery	?	Non-Mastery		Mastery	?	Non-Mastery		Mastery	?	Non-Mastery	
		(5-6)	(4)	(2-3)	(0-1)	(5-6)	(4)	(2-3)	(0-1)	(5-6)	(4)	(2-3)	(0-1)	(5-6)	(4)	(2-3)	(0-1)
Grade 1	C N = 30	6	6	7	11	0	7	8	15	12	7	7	4	4	6	9	11
	E N = 30	4	6	8	12	0	5	9	16	12	9	6	3	9	8	6	7
	Combined N = 60	10	12	15	23	0	12	17	31	24	16	13	7	13	14	15	18
Grade 2	C N = 28	12	5	1	10	3	9	4	12	18	8	2	0	8	7	8	5
	E N = 30	5	4	10	11	0	6	7	17	14	7	7	2	14	3	6	7
	Combined N = 58	17	9	11	21	3	15	11	29	32	15	9	2	22	10	14	12
Grade 3	C N = 29	9	6	6	8	2	8	7	12	18	10	1	0	13	5	8	3
	E N = 30	8	10	5	7	2	10	9	9	17	8	4	1	10	7	10	3
	Combined N = 59	17	16	11	15	4	18	16	21	35	18	5	1	23	12	18	6
All Grades Combined	C N = 87	27 (31%)	17 (18%)	43 (51%)		5 (6%)	24 (26%)	58 (68%)		48 (55%)	25 (29%)	14 (16%)		25 (28%)	18 (20%)	44 (51%)	
	E N = 90	17 (19%)	20 (22%)	53 (59%)		2 (2%)	21 (23%)	67 (75%)		43 (48%)	24 (27%)	23 (25%)		33 (37%)	18 (20%)	39 (43%)	
	Total N = 177	44 (25%)	37 (20%)	96 (55%)		7 (4%)	45 (25%)	125 (61%)		91 (51%)	49 (28%)	37 (21%)		58 (33%)	36 (20%)	83 (47%)	

Note: A score of 5 or 6 resulted in classification under mastery; a score of 4 was judged borderline; and a score of 3 or below resulted in classification under non-mastery. See Chapter 4 for explanation of method of obtaining score.

TABLE 5-2
MEAN SCORES AND STANDARD DEVIATIONS ON FOUR BASIC PRINCIPLES, ON SUPPOSITIONAL AND FACTUAL ASPECTS, AND ON TOTAL TEST

Grade	Group & No.	Statistic	Inversion (6 items)			Conversion (6 items)			Contraposition (6 items)			Transitivity (6 items)			Total (24 items)		
			S*	F*	S+F	S	F	S+F	S	F	S+F	S	F	S+F	S	F	S+F
1	C* N=30	Mean	1.1	1.5	2.6	.80	.90	1.7	1.8	2.1	3.9	1.1	1.5	2.6	5.1	6.0	10.7
		S.D *	1.1	1.2	2.1	.81	1.9	1.6	1.0	.88	1.8	1.0	.9	1.8	3.2	2.5	5.1
	E* N=30	Mean	1.0	1.2	2.2	.77	.73	1.5	1.7	2.2	3.9	1.4	1.7	3.1	4.9	5.9	10.8
		S.D.	1.1	1.0	2.0	.73	.83	1.5	.88	.76	1.5	.97	1.1	1.9	2.6	2.4	4.9
	C+E N=60	Mean	1.1	1.4	2.4	.78	.82	1.6	1.7	2.2	3.9	1.2	1.6	2.5	5.0	5.9	10.7
		S.D.	1.1	1.1	2.0	.76	.85	1.5	.94	.82	1.6	1.0	1.0	1.8	2.9	2.5	4.9
2	C N=28	Mean	1.5	1.9	3.5	1.1	1.3	2.5	2.2	2.7	4.9	1.6	1.8	3.4	6.6	7.7	14.3
		S.D.	1.3	1.1	2.3	1.1	1.1	2.0	.69	.46	1.0	1.1	1.9	1.9	3.2	2.4	5.5
	E N=30	Mean	1.0	1.5	2.5	.60	.87	1.5	1.8	2.4	4.2	1.8	1.9	3.7	5.3	6.6	11.8
		S.D.	1.1	1.0	2.0	.86	.94	1.7	1.1	.76	1.6	1.1	1.2	2.2	2.9	2.4	5.0
	C+E N=58	Mean	1.3	1.7	3.0	.88	1.1	2.0	2.0	2.5	4.5	1.7	1.8	3.6	5.9	7.1	13.0
		S.D.	1.2	1.1	2.2	.99	1.0	1.9	.92	.65	1.4	1.1	1.1	2.0	3.0	2.4	5.3
3	C N=29	Mean	1.5	1.6	3.0	1.1	1.0	2.0	2.5	2.6	5.1	2.0	2.0	4.0	7.0	7.0	14.1
		S.D.	1.2	1.2	2.3	.98	.96	1.9	.57	.50	1.0	1.0	1.1	2.0	2.8	2.7	5.4
	E N=30	Mean	1.5	1.8	3.3	1.2	1.2	2.4	2.3	2.5	4.7	1.8	1.9	3.7	6.8	7.3	14.2
		S.D.	1.1	1.0	2.0	.90	.92	1.8	.78	.78	1.4	.9	1.0	1.8	2.6	2.5	4.9
	C+E N=59	Mean	1.5	1.7	3.3	1.2	1.1	2.3	2.4	2.5	4.9	1.9	1.9	3.8	7.0	7.2	14.2
		S.D.	1.1	1.1	2.1	.93	.94	1.8	.70	.65	1.2	.9	1.0	2.0	2.6	2.5	5.0
All 3 Combined	C N=87	Mean	1.4	1.7	3.0	1.0	1.1	2.0	2.2	2.4	4.6	1.6	1.8	3.3	6.2	6.9	13.0
		S.D.	1.2	1.2	2.3	.95	.99	1.9	.83	.69	1.4	1.1	1.0	2.0	3.1	2.6	5.5
	E N=90	Mean	1.2	1.5	2.7	.87	.93	1.8	1.9	2.3	4.3	1.7	1.8	3.5	5.7	6.6	12.3
		S.D.	1.1	1.0	2.0	.86	.91	1.7	.94	.77	1.5	1.0	1.1	2.0	2.8	2.5	5.1
	C+E N=187	Mean	1.3	1.6	2.9	.94	1.0	1.9	2.0	2.4	4.4	1.6	1.8	3.4	6.0	6.8	12.7
		S.D.	1.2	1.1	2.1	.90	.94	2.9	.89	.73	1.5	1.0	1.0	2.0	3.0	2.5	5.3

*'S' = 'suppositional'; 'F' = 'factual'; 'S.D.' = 'estimated population standard deviation'; 'C' = 'control'; 'E' = 'experimental'.

students--some are good at logic and some are not. Six first graders have mastered inversion while nineteen have not; twelve second graders have and eleven have not; nine third graders have and fifteen have not. It does then seem to be an oversimplification to talk, as Piaget does, about the child from 7-8 to 11-12, as if children in this age range, or at any age level within it, were pretty much the same.

Table 5-3 presents significance tests done on the differences among scores on principles, between the suppositional and factual halves of the test, and between the validity and fallacy principles. All the differences are statistically significant (using 5% level), but in addition the differences among the principles and between the validity and fallacy principles are practically significant. Thus, there is good reason not to speak simply of ability to handle conditional (or propositional) logic, but rather to speak of a particular aspect of conditional (or propositional) logic. As might have been expected from our earlier study, children do better on the validity principles, and in particular are worst at conversion.

Contraposition comes out better than transitivity perhaps because of an "atmosphere effect" (see Chapter 1), but more probably because of the added complexity of transitivity. The atmosphere effect might work through the negative atmosphere provided by the denial of the then-part, which might suggest the valid move: the denial of the if-part. That is, the negative flavor might be operative rather than validity considerations. The trouble with this explanation is that one would then expect this negative atmosphere to operate in inversion as well, bringing forth incorrect answers, and perhaps making inversion harder than conversion--something that definitely

TABLE 5-3
COMPARISONS OF CONTROL GROUP PART SCORES
N = 87 (d.f. = 86)

Comparisons		Mean	Difference	t	Superiority Indicated (All differences are significant.)
1.	A. Fallacy Principles	5.06	2.87	6.8	
	B. Validity Principles	7.93			X (Validity Principles)
2.	A. Suppositional Items	6.21	0.68	4.1	
	B. Factual Items	6.89			X (Factual Items)
3.	A. Inversion	3.01	0.97	5.6	X (Inversion
	B. Conversion	2.04			
4.	A. Inversion	3.01	1.60	6.5	
	B. Contraposition	4.61			X (Contraposition)
5.	A. Inversion	3.01	0.29	3.4	
	B. Transitivity	3.30			X (Transitivity)
6.	A. Conversion	2.04	2.57	12.2	
	B. Contraposition	4.61			X (Contraposition)
7.	A. Conversion	2.04	1.26	5.2	
	B. Transitivity	3.30			X (Transitivity)
8.	A. Contraposition	4.61	1.31	6.8	X (Contraposition)
	B. Transitivity	3.30			

Critical Values for Two-Tailed t Tests

Degrees of Freedom	Levels of Significance .05	.01
60	2.00	2.66
120	1.98	2.62

did not happen, as can be seen in Tables 5-1, 5-2, and 5-3.

The complexity of the transitivity arguments better explains the greater difficulty of transitivity, as compared to contraposition. It is presumably more difficult to keep in mind two conditional premises than just the one required in contraposition. This difficulty was unfortunately accentuated by our not providing a visual reminder of the transitivity premises in the chemicals part of the test (two items). A visual reminder was provided in all other cases.

This complexity plus lack-of-reminder explanation of the poorer performance on transitivity as compared to contraposition might also explain why transitivity was not much better than inversion. (As a matter of fact, a few more students mastered inversion than transitivity--although the mean score on transitivity was higher.) We do not have an explanation of student superiority on one fallacy principle (inversion) as compared to the other fallacy principle (conversion).

SUPPOSITIONAL ABILITY

As can be seen in Table 5-3, the mean factual item score is statistically significantly higher than the suppositional item score. An inspection of Table 5-2 shows that students consistently did better on the factual items than the suppositional items. Two possible explanations occur to us, a "test-mechanics" explanation and a "real-possible" explanation.

The test-mechanics' explanation is based on the fact that in all cases the suppositional item preceded the factual item. The test was arranged this way in order that the same content could be used for each pair of items. We could not reverse the order using the same content, because to do so would require a student to only suppose what he already knows.

In the order of actual presentation students were first asked to suppose the minor premise (which sometimes was obviously false, as when they were asked to suppose that there was a powder in an empty beaker, which powder does not bubble when vinegar is added); after being asked what to make of that supposition and to justify their answer, they were then shown the factual counterpart of the supposition (for example, they were shown a beaker with a powder in it, to which vinegar was added, producing no bubbling; and they were asked again what to make of the situation). The difficulty with this approach is that it is parallel to test-retest situations, in which students generally improve even though they have had no instruction. Hence, we cannot be sure that suppositional ability is lower than factual ability.

The real-possible explanation is Piagetian (1958, pp. 254-55) in flavor--but without the burden of his stages and heavy dependence on chronological age. This explanation holds that it is more difficult to work with possibilities than with known reality. Since suppositional items call for working with possibilities, we would, according to his explanation, expect the superiority on the factual items that we found.

It is difficult to choose between these alternative explanations. We suspect that each accounts in part for the differences we found. But it is not difficult to see that at least some suppositional ability was demonstrated by even our youngest students. For example, four of our thirty first graders answered correctly all three suppositional inversion items and eight answered correctly all three suppositional contraposition items (See Table 5-4). Since a right answer and a good justification were necessary for any credit on an item, these figures indicate clearly that there is suppositional ability among first graders.

TABLE 5-4
COUNTS OF STUDENTS WHO HAD SPECIFIED NUMBERS OF CORRECT ANSWERS ON SUPPOSITIONAL AND FACTUAL ITEMS

Principle:		Inversion						Conversion						Contraposition						Transitivity					
Number Correct:		3		2		1-0		3		2		1-0		3		2		1-0		3		2		1-0	
Form:		S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
Grade 1	C N = 30	4	7	7	10	19	13	0	0	7	10	23	20	8	11	11	12	11	7	3	3	8	13	19	14
	E N = 30	3	3	7	11	20	16	0	0	5	7	25	23	4	11	17	15	9	4	3	8	13	12	14	10
Grade 2	C N = 28	9	12	8	6	11	10	3	3	9	15	16	10	10	20	14	8	4	0	7	6	10	12	11	10
	E N = 30	5	6	3	9	22	15	0	0	7	11	23	19	10	15	8	12	12	3	11	12	7	8	12	10
Grade 3	C N = 29	7	9	9	7	13	13	2	1	8	9	19	19	16	16	12	13	1	0	11	13	9	7	9	9
	E N = 30	5	8	14	12	11	10	1	1	13	13	16	16	14	18	10	9	6	3	9	10	8	10	13	10
Total	C N = 87	20	28	24	23	43	46	5	4	24	34	58	49	34	47	37	33	16	7	21	22	27	32	39	33
	E N = 90	13	17	24	32	53	41	1	1	25	31	64	58	28	44	35	36	27	10	23	30	28	30	39	30

RELATIONSHIPS WITH OTHER FACTORS: SEX, AGE, SOCIOECONOMIC STATUS, I.Q., AND DWELLING AREA

Tables 5-5 and 5-6 are Pearson product-moment correlation matrices showing the relationships between a variety of factors and scores on our test for both control and experimental groups.

Sex.

There appears to be little or no relationship between the sex of the children and anything else that we examined, as we expected. Correlations of -.13 and .03 were obtained between sex and total score.

Age.

The correlations between logic scores and chronological age (.15 and .19) came out lower than we expected, having secured a correlation of .58 between chronological age and conditional logic for children ages 10-18 in our earlier study. The fact that the age range in the present study is three instead of eight years might account for the lower correlations this time. Another possibility is that there is a plateau in development within our age range. This plateau theory is supported by the fact that second grade scores are about as high as third grade scores, with fairly large differences between first and second graders. The mean total score of our second grade control group, for example, is actually higher than that of the third grade control group (14.3 to 14.1; see Table 5-2), and the first grade score is considerably lower (10.7).

Table 5-7 shows the results of a more sophisticated comparison, using analysis of covariance, in which the second grade's superiority, when adjusted for I.Q. and socioeconomic status differences, has been lost, but the superiority of the third grade's adjusted mean is rather small. Adjusted

TABLE 5-5
CONTROL GROUP* CORRELATION MATRIX: FACTORS AND TEST SCORES

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal IQ	Performance IQ	Total IQ	Inversion	Conversion	Contraposition	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.03	1.0																	
Chronological Age	-.02	0.0	1.0																
Suppositional Items	-.14	.36	.19	1.0															
Factual Items	-.15	.43	.12	.86	1.0														
Fallacy Principles	-.10	.35	.02	.78	.87	1.0													
Validity Principles	-.12	.38	.33	.75	.69	.34	1.0												
Chemicals Items	-.15	.41	.13	.85	.90	.90	.59	1.0											
House Items	-.05	.34	.29	.77	.75	.53	.81	.52	1.0										
Verbal IQ	-.15	.38	-.17	.53	.56	.53	.38	.56	.40	1.0									
Performance IQ	-.17	.29	-.08	.32	.31	.25	.30	.31	.25	.61	1.0								
Total IQ	-.18	.39	-.14	.48	.49	.45	.39	.49	.38	.92	.87	1.0							
Inversion	-.04	.30	.00	.73	.80	.94	.27	.82	.48	.50	.23	.42	1.0						
Conversion	-.16	.35	.04	.71	.82	.91	.37	.85	.50	.49	.22	.41	.71	1.0					
Contraposition	-.11	.35	.29	.65	.58	.31	.81	.53	.63	.38	.28	.37	.28	.30	1.0				
Transitivity	-.08	.33	.27	.64	.59	.26	.90	.47	.76	.31	.25	.33	.18	.31	.48	1.0			
Total Score	-.13	.44	.19	.93	.96	.87	.76	.93	.79	.57	.33	.51	.79	.82	.64	.65	1.0		
Area**	-.06	.56	.09	.23	.24	.19	.26	.28	.18	.25	.30	.33	.16	.21	.29	.19	.27	1.0	
Grade	.07	.06	.89	.25	.17	.07	,38	.19	.28	-.01	-.01	-.01	.07	.06	.35	.29	.25	.02	1.0

*N = 87.

**Urban = 1, Rural = 2, Suburban = 3.

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TABLE 5-6
EXPERIMENTAL GROUP* CORRELATION MATRIX: FACTORS AND TEST SCORES

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal IQ	Performance IQ	Total IQ	Inversion	Conversion	Contraposition	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.03	1.0																	
Chronological Age	-.10	-.20	1.0																
Suppositional Items	.08	.22	.17	1.0															
Factual Items	-.04	.23	.12	.85	1.0														
Fallacy Principles	-.04	.20	.16	.77	.83	1.0													
Validity Principles	.09	.17	.08	.80	.71	.32	1.0												
Chemicals Items	-.02	.26	.17	.89	.87	.89	.58	1.0											
House Items	.10	.12	.06	.74	.74	.43	.83	.44	1.0										
Verbal IQ	-.08	.51	-.25	.49	.50	.41	.43	.48	.39	1.0									
Performance IQ	.01	.51	-.36	.33	.35	.17	.42	.33	.27	.65	1.0								
Total IQ	-.04	.56	-.33	.46	.48	.33	.46	.45	.37	.93	.89	1.0							
Inversion	.07	.18	.13	.70	.78	.90	.31	.77	.48	.37	.16	.30	1.0						
Conversion	-.15	.18	.17	.66	.69	.86	.24	.81	.26	.36	.14	.28	.56	1.0					
Contraposition	.17	.11	.10	.67	.54	.26	.80	.53	.57	.33	.41	.40	.30	.15	1.0				
Transitivity	.00	.17	.04	.68	.65	.27	.88	.46	.81	.39	.31	.39	.23	.25	.42	1.0			
Total Score	.03	.24	.15	.97	.96	.83	.79	.91	.77	.52	.36	.49	.77	.70	.64	.69	1.0		
Area**	.08	.64	-.07	.20	.16	.13	.17	.22	.08	.37	.34	.39	.13	.11	.18	.11	.19	1.0	
Grade	-.05	.07	.89	.29	.24	.25	.20	.28	.17	-.08	-.20	-.15	.22	.23	.22	.12	.28	-.03	1.0

*N = 90.

**Urban = 1, Rural = 2, Suburban = 3.

TABLE 5-7
COMPARING GRADES ONE, TWO, AND THREE
IN CONDITIONAL LOGIC, USING ANALYSIS OF COVARIANCE*

Principle	Adjusted Means			F
	Grade 1 N = 30	Grade 2 N = 28	Grade 3 N = 29	
Inversion	2.7	3.4	3.2	.916
Conversion	1.8	2.4	2.1	1.006
Contraposition	3.9	4.9	5.1	8.009
Transitivity	2.6	3.3	3.9	3.771
Total	11.0**	14.0	14.4	5.313

NOTES: Underlined F's mean statistically significant (using 5% level) differences among grades. For d.f. (2,82), F must be greater than 3.11 (4.88) for significance at the 5% (1%) level. Total N = 87.

*Covariates: I.Q. and SEI.

**Principle and total adjusted means are computed separately and are not necessarily additive.

means for first, second, and third grades are 11.0, 14.0, and 14.4, respectively. There is a statistically significant difference among grades, but the plateau theory could still account for the facts, since second and third grades are so close.

The results of O'Brien and Shapiro (1968) show a somewhat similar pattern for validity items: large jump from first to second grade, possible retrogression from second to third; but for fallacy items they did not get this pattern. We did get it with fallacy items (see inversion and conversion principles in Tables 5-2 and 5-7), and are not sure how to explain the discrepancy.

The plateau theory that would explain our data should be distinguished from a stages theory. According to a stages theory virtually no children at a given stage should be able to do something. Using chronological age none of our children should be able to handle conditional logic, if the conditional logic stage does not begin until 11-12. If one substitutes mental age for chronological age, but still retains the stages aspect, then there should be a regular improvement in mean scores every year, given that some of a group are already in the stage, since there is a regular improvement in mental age every year. That is, once a reasonable number of a group are in a stage (as is the case with our group), then each year more should be in the stage, since each year mental age develops.

In our (admittedly speculative) plateau theory, the plateau represents an arrest in development of almost all children at a particular chronological age range; even though some are already rather well developed, they develop no further, and those only partially developed stop developing, also. This arrest in development could have an environmental basis (e.g., our culture inhibits logical growth after children have been in primary school for a while), or it could have a genetic basis (logical development can come, if at all, only up through the age range 7-8, and then it stops for a while).

We urge that more research be done on this intriguing topic, and for the time being only assert that we found at ages 6-9 a surprisingly low but positive overall relationship between chronological age and conditional logic ability.

Our current developmental results are not inconsistent with the results of our previous study of older children (see Chapter 1), where we found clear superiority of validity principles over fallacy principles, where we found that inversion seemed easier than conversion (although this did not show itself among the younger children of that study, presumably because of the difficulty of the test), and in which we found a fairly regular development as children grew older. Because different tests were used and because fourth graders were skipped, the other study throws little light on the plateau theory, and it offers no clear support for the theory.

The test in the earlier study, a paper and pencil test, apparently is considerably more difficult than the test used in the current study, since, although the trends are the same, there would be a severe retrogression from third to fifth grade if the tests were equally difficult. (See Tables 1-1, 1-2, 5-1, and 5-2.)

The incompatibility between the earlier study and the current one lies in the use of the same criterion for mastery (at least five right out of six), when it seems clear that the consistent use of this criterion results in a judgment of retrogression from third to fifth grades. We have not yet resolved this problem.

Some possible resolutions are as follows:

1. To judge that the two tests are actually indicative of different levels of mastery, say "medium-level mastery" and "low-level mastery".
2. To change the operational definition used for one or both of the tests. For example, one might judge that on the "Cornell Conditional Reasoning Test, Form X", one demonstrates mastery on a principle by getting at least four items right out of six. Alternatively, one might judge that on the "Smith-Sturgeon Conditional Reasoning Test" one only demonstrates mastery by getting all six items right in a group.
3. By abandoning the mastery approach altogether and simply reporting numbers.

Socioeconomic Status.

A positive relationship between socioeconomic status and conditional logic ability is indicated by Pearson product-moment correlations of .30, .35, .35, .33, and .44 between socioeconomic status and inversion, conversion, contraposition, transitivity, and total score, respectively (Table 5-5); somewhat lower correlations were obtained for the experimental group: .18, .18, .11, .17, and .24. Perhaps the instruction made up in part for socioeconomic differences, even though its overall effect appears to be nil. That there is a relationship between socioeconomic status and conditional logic ability does in any case seem clear.

I.Q.

Correlations with I.Q. (WISC) scores were the highest obtained between conditional logic and other factors, verbal I.Q. coming out higher than performance I.Q. and total I.Q. Correlations of .57 and .52 between total score and verbal I.Q. for control and experimental groups are indicative of the situation (Tables 5-5 and 5-6). Table 5-8 shows that for the second and third grades taken separately the correlations are higher; the verbal I.Q. correlations in the low sixties are surprisingly high in view of the fact that there are no deductive logic items on the WISC.

TABLE 5-8
CORRELATIONS BY GRADES BETWEEN WISC I.Q. AND TOTAL SCORE
FOR CONTROL AND EXPERIMENTAL GROUPS

Grade	Group	Verbal I.Q.	Performance I.Q.	Total I.Q.
1	C N = 30	.50	.12	.37
	E N = 30	.45	.25	.42
2	C N = 28	.64	.38	.59
	E N = 30	.63	.45	.63
3	C N = 29	.62	.43	.58
	E N = 30	.64	.58	.63

Dwelling Area.

A comparison of dwelling areas is a tricky thing to interpret, because other factors, especially socioeconomic status, vary with dwelling areas, and because this variation itself varies, given the rough categorization that we used for dwelling areas: urban, rural, suburban. For example, some urban areas are heavily upper class, while some are heavily lower class. In view of this variability from one place to the next, particular caution must be exercised in interpreting our results. Our basic comparison was done by analysis of covariance, compensating for I.Q., socio-economic status, and age. With statistical compensation for these factors we found no significant difference among the three dwelling areas. See Table 5-9 for a summary. Perhaps with a larger sample, statistical significance would have appeared, favoring urban areas over rural areas, but we do not know.

Another note of caution should be sounded: One should not infer from this comparison that a particular sort of area is a better place to raise one's children from the point of view of developing their logical ability; nor should one infer that it does not matter what sort of area one chooses, given an interest in logical ability. By statistically eliminating I.Q., socio-economic status, and age, we have created an artificial comparison. One would have to look for a very long time to find three areas, one urban, one rural, and one suburban, in which these factors are actually about the same. Furthermore, there probably are complicated causal interactions which have been obliterated by statistically eliminating the three factors. All that one can conclude, and this only tentatively, is that being in a rural area or being in an urban area is not by itself a significant deterrent to acquisition of logical ability.

READINESS

Although it is very interesting to know what it is that percentages of children at various levels are capable of, it is frustrating as well, because one would like to be able to assume that almost all of some given group have mastered some prerequisite principle before one goes ahead with the presentation of instruction in that for which the principle is prerequisite. Now one can just wait until mastery of such principles somehow or other

TABLE 5-9
COMPARISONS OF URBAN, RURAL, AND SUBURBAN CHILDREN
BY ANALYSIS OF COVARIANCE*

Principle	Adjusted Means			F
	Urban N = 58	Rural N = 59	Suburban N = 60	
Inversion	3.5	2.7	3.1	1.1
Conversion	2.4	1.7	2.2	1.0
Contraposition	4.6	4.4	4.8	.8
Transitivity	3.5	3.2	3.2	.2
Total Score	14.0**	11.9	13.3	1.6

NOTE: For significance at the 5% (1%) level the F statistic must be greater than 3.11 (4.88) for d.f. of 2,80.

*Covariates: I.Q., SEI, and Age.
**Principle and total adjusted means are computed separately and are not necessarily additive.

develops, a plan which apparently would not work for the conditional logic fallacy principles, according to our previous study of older children (Ennis and Paulus, 1965). Or one can try to bring about the prerequisite mastery.

On the basis of our data, we conclude that the methods which we used to try to bring about the mastery of the four basic principles of conditional logic were not successful. Table 5-10 gives a summary of the variety of comparisons that we made using analysis of covariance. Of the thirty comparisons only one is statistically significant, and that one (contraposition in the suburban area) favors the control group.

The generally lower correlations between socioeconomic status and conditional logic that we found for the experimental group (Tables 5-5 and 5-6) suggested that our instruction might have compensated in part for socioeconomic backgrounds, but we see little corroboration of this suggestion in the analysis of covariance comparisons between experimental and control groups. It is true that in the areas with more lower status children (urban and rural) the experimental groups did at least as well as the control groups in adjusted means while in the area with predominantly higher status children the control group did a little better. But this does not constitute an argument for the conclusion that our instruction was effective for lower status children. Actually our instruction could have hurt higher status children.

One wonders why the instruction did not succeed. One possible answer is Piagetian in flavor: It did not succeed because mental abilities develop and unfold on their own and cannot be hastened. The trouble with this answer is that we clearly did succeed in instructing upper secondary children in our earlier study; we did hasten their acquisition of knowledge of conditional logic. A second possible explanation is that children this

TABLE 5-10
EXPERIMENTAL-CONTROL GROUP COMPARISONS BY GRADES AND DWELLING AREAS, USING ANALYSIS OF COVARIANCE

		Adjusted Means and F's									
		Inversion		Conversion		Contraposition		Transitivity		Total	
		AM**	F	AM	F	AM	F	AM	F	AM	F
Grade 1	C N = 30	2.6	.6	1.7	.4	3.9	.0	2.6	1.0	10.9*	.0
	E N = 30	2.2		1.5		3.9		3.1		10.6	
Grade 2	C N = 28	3.1	.3	2.2	1.2	4.7	1.2	3.1	3.1	13.2	.1
	E N = 30	2.8		1.7		4.3		4.0		12.9	
Grade 3	C N = 29	3.1	.2	2.0	1.0	5.0	.8	3.8	.0	14.1	.1
	E N = 30	3.4		2.5		4.8		3.8		14.4	
Urban	C N = 29	2.8	.1	1.8	.1	4.1	.1	2.8	2.1	11.6	.0
	E N = 29	2.6		1.7		4.0		3.4		11.7	
Rural	C N = 29	2.6	.2	1.7	.0	4.2	.4	3.0	.6	11.5	.1
	E N = 30	2.4		1.7		4.4		3.4		11.9	
Suburban	C N = 29	3.6	.6	2.6	1.0	5.2	4.9	3.7	.4	15.1	1.2
	E N = 31	3.2		2.2		4.6		4.0		14.0	

NOTE: With d.f. (1,55) an F statistic greater than 4.02 (7.17) is necessary for significance at the 5% (1%) level.

*Covariates: I.Q. and SEI.
**Principle and total adjusted means are computed separately and are not necessarily additive.

young cannot learn basic principles of conditional logic. The trouble with this explanation is that so many have already learned conditional logic, as shown in Tables 5-1, 5-2, and 5-4, and discussed earlier. Another possible explanation is that children at this level cannot be taught conditional logic, although they might acquire it on their own, and although older children can be taught it. A fourth possible explanation is that our teaching materials were inadequate. We have at present no firm way to choose between the third and fourth possible explanations. As we indicated earlier, one of the peculiarities about a readiness study is that negative results do not easily show that children are not ready, while positive results easily show that they were ready.

Because of the difficult abstract learning that children accomplish in early mathematics, science, and reading, we lean toward the view that we just have not found a successful set of materials for instruction in conditional logic. One thing appears to be intuitively clear: We will need many, many simple examples, just as mathematics instruction provides many, many examples.

TYPICALITY

The question of generalizability of results to a population beyond that from which the sample was drawn is one not often enough raised in educational research, but it cannot be escaped. That we took random samples from the classrooms involved gives one fairly good grounds for generalizing to the entire population consisting of those classrooms; but that population is small compared to that in which we are interested.

Given the limited means that we had, we did the best we could to get a variety of American children. We do have slum children, ghetto children, farm children, skilled laborer's children, clerk's children, and professor's children; we have rich children and poor children; we have culturally deprived and culturally advantaged children; but all these children are resident in upper New York State. We have no sizeable representation from the South, the West, or the Midwest. We have no children for whom English is a weak second language--or who speak no English at all. And we do not have children who live in daily fear of attack on the streets.

In Chapter 5 we have tried to tell something about the children we studied. We cannot endorse generalization to different types of children.

CHAPTER 6
SUMMARY

INTRODUCTION

The Cornell Critical Thinking Project asks and attempts to answer questions about human thinking and reasoning. Predicated on the notion that all society benefits from reasoned critical thinking, the Project also explores possibilities for the enhancement of critical thinking ability.

In Phase IIC we were interested in learning about the ability of early primary grade children to think logically. In keeping with the long-range purposes of the Project we were also interested in children's potential for greater development. Specifically, we wanted answers to these two questions: (1) How much conditional logic has been acquired by children, ages 6-9, from a range of socioeconomic and environmental backgrounds? (2) Are they ready to learn more? Fundamental to our approach was the belief that a knowledge of conditional logic is central to all critical thinking.

The first step in our investigation was the establishment of acceptable control and experimental groups. Our children came from three elementary schools with three distinct flavors; one urban, another rural, the third, suburban.

Groups were established in such a way that for each grade we selected thirty control children and thirty experimentals (ten controls and ten experimentals from each of the three schools).

INSTRUCTION

The basic task of subject selection completed, our experimental design was essentially two-phased. The first phase consisted of involving the children designated as experimental in a series of fifteen lessons designed to impart a knowledge of conditional logic. Rather than presenting the logic instruction in theoretical form, the lessons had a science content which served as a medium for the illustration of logical principles.

The lessons were audio-tutorial. Each child, alone in a carrel, was given a set of materials to observe and manipulate, and a tape recording which guided the lesson and asked questions relating to the materials.

The Project staff considered the development and preparation of the lessons, in addition to its practical use in the total experimental design, to be an important part of Phase IIC. It was hoped that these instructional materials would make a contribution to the teaching of logic.

TESTING

Phase two of the experimental design was devoted to testing. In testing the control children we intended to be discovering how much understanding of logic children of these grades have independently acquired. By comparing the control children's performance with that of the experimentals, we could make decisions about the effectiveness of our instruction, and perhaps draw inferences as to the readiness of children of these ages to learn more logic.

The test was designed to measure the child's understanding of four basic principles of deductive logic: inversion, conversion, contraposition, and transitivity. To accomplish this measurement, an individually administered test consisting of two discrete parts and a total of twenty-four questions was developed. The house part of the test presented the child with a small model house and certain information about the relationship of the two electric switches on the house to a buzzer and a light on the front and side of the model.

The child was asked to make conclusions based on conditional statements related to the information he had been given.

In the chemicals part of the test, a relationship was demonstrated between the action of certain liquids on certain powders, and, as in the house test, the child was asked to make conclusions based on related conditional statements.

Questions were always asked in a pair. The first question of the pair was stated in suppositional terms; that is, without the relevant situation actually being demonstrated, the child was asked to imagine such a situation and base his answer on that supposition. The second question restated the first, but this time in factual terms. The child was asked for a conclusion after the relevant situation had actually been demonstrated.

In answering a question the child was given three possible answers from which to choose. Credit was given only if the child provided satisfactory verbal justification for his correct choice.

ANALYSIS OF DATA

In measuring the performance of the children, it was decided that analysis would focus on the concept of mastery. Six questions on the test related to each of the four principles of logic. Operational definitions of mastery called for a judgment that the child who answered five or six of the questions had mastered the principle; called for no judgment in the case of four correct answers; and called for probable non-mastery when a child made three or fewer correct responses.

Other information was obtained about each child in addition to mastery data. This included school, grade level, chronological age, sex, I.Q. (Wechsler Intelligence Scale for Children), conditional logic total score and subscores, and a rough estimate of socioeconomic status (the Warner occupation scale, amended).

Our most important tool of data analysis was a set of simple counts of items answered correctly. Correlations between test performance and demographic characteristics were also determined. Other analyses of the data included difficulty and discrimination indices, Kuder-Richardson tests for reliability, and a Campbell and Fiske test for validity. Experimental-control group comparisons used analysis of covariance. Comparisons among conditional logic subscores used simple t-tests.

CONCLUSIONS

Perhaps the most interesting conclusion drawn from our analysis is that many children of these early primary grades have already successfully mastered principles of conditional logic. The fact that fifty-five per cent of our control children showed mastery of the contraposition principle is counterevidence to Piaget's claim that children are incapable of doing propositional logic.

Other observations to be made include the following:

1. Children can handle factual questions slightly better than suppositional ones, validity principles considerably better than fallacy ones.
2. There seems to be little or no relationship between conditional logic ability and sex.
3. Though some relation between chronological age and ability in conditional logic exists, the relationship is not a strong one.
4. A stronger relationship exists between socioeconomic status and conditional logic ability.
5. Even stronger is the relationship between I.Q., especially verbal I.Q., and conditional logic ability.

6. Our results indicated that those children who received our series of lessons performed no better than children in the control group.

The interpretation of this last finding is of particular importance. On the one hand it could be suggested that children of these ages are not ready to learn more conditional logic. However, the failure of the experimental group to outperform the controls may not be the result of the children's innate lack of capacity for the expansion of skills of conditional logic reasoning. Rather, the shortcoming may lie in our mode of instruction. The question of whether children of early primary grades are ready to learn more conditional logic remains unanswered. The invitation to the generation of more questions and the search for more answers is clear.

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APPENDIX A

Conditional Reasoning/Energy, Script 10

Content and Materials for the Lessons

CONDITIONAL REASONING/Energy
Script 10

Another time when you came to this booth to learn about science, you changed kinetic energy into electrical energy by using a hand crank generator. Today you are going to make electrical energy a different way.

Find the little white box back under the shelf. Move that white box to the word 'science', now. In that box are three things: a battery, a blue wire fastened to a small light bulb, and a red wire. Pick up the battery, now. Place it down on the table, on its side.

Now pick up the blue wire attached to the light bulb. Leave the red wire in the box. Move the white box back under the shelf.

Now, try to make the bulb light up. Use the battery and the blue wire to make the bulb light up. [Pause.]

If you find one way to light up the bulb, then try to find another way. Use only the blue wire and the battery. [Pause.]

Put the bulb and the battery down on the table now. On the wall of your booth over the tape recorder is a cardboard pocket. Take the white card out of that pocket. On the back of that white card is a picture. Put the card on the table, with the picture facing up. Look at the picture on the card. That picture shows one way to light up the little bulb.

Try now to light up the bulb just the way it shows in the picture. [Pause.]

Now put the bulb and battery down on the table. Look at the picture again. The picture shows the wire, bulb, and the battery connected together. When batteries and bulbs are connected together by wires, they make an electric circuit. An electric circuit is a path for electricity.

Look at the picture of the path or circuit for the electricity. Put your finger on the green arrow on the picture. That green arrow points to the place where electricity comes out of the battery. The electricity comes out of the silver colored metal part on the bottom of the battery. Then it goes into the end of the wire.

Now pick up the real blue wire and bulb. Look at the end of the real wire. See that silver colored metal part. That metal part goes all the way through the wire. The blue part of the wire is just an outside covering. You can put the wire and bulb down, now.

Now look at the picture again. Put your finger on the picture of the end of the wire near the green arrow. Now move your finger along the picture of the blue wire. Move your finger along the picture of the wire to the bulb. That's just the way the electricity goes.

Now put your finger on the yellow arrow. That yellow arrow points to where the electricity goes. It comes out of the blue wire and goes into those tiny wires inside the glass part of the bulb.

Now put your finger on the blue arrow on the picture. The blue arrow is pointing right at where the electricity goes from the bulb back into the battery.

The electricity started in the battery. Then it went to the blue wire. It went from the blue wire to the bulb. Then it went back into the battery again. The electricity can go around that path or circuit and come back to the battery. Move your finger around the picture of that circuit. Start on the picture of the battery. Then move it down to the blue wire. Move your finger up along the picture of the blue wire to the picture of the bulb. Now move your finger right down to the battery.

To make the light bulb light you have to have the end of the wire touching one end of the battery and the bottom of the bulb touching the other end. This makes a complete circuit. A complete circuit is a path where electricity can go around and come back to where it started again. Whisper with me twice the kind of circuit you have to have to make a bulb light. [Whisper...] A complete circuit, a complete circuit.

Move your finger around the complete circuit in the picture, again. Move your finger from the battery, along the wire, to the bulb, and back to the battery again.

Now make a complete circuit with the real bulb, the wire, and battery.

[Pause.] This time observe the parts of the bulb inside the glass part of the bulb. Did you see where the electrical energy changes into light energy? Try it once more. Try to see where the electrical energy changes into light energy. [Pause.]

Now, look at the picture once more. Point to the picture of the part of the bulb where the electrical energy changes into light energy. Are you pointing to that tiny part of the bulb that the yellow arrow is pointing to? The yellow arrow is pointing to the part of the bulb where the electrical energy changes into light energy. It is pointing to that tiny little wire.

Now put that card with the picture on it back up in its pocket.

We can make a true if-then sentence about the bulb. We can say, if the bulb is lighted up, then the circuit is complete.

Find the big cardboard folder back under the shelf. Move it to the word 'science', now. Open the folder and look at the words and pictures inside.

Those words are the if-then sentence I just told you. Point to the tall word with two yellow lines under it. That word is 'if'. Now put your finger under the words that have one yellow line under them. Those words are the if-part of the if-then sentence. They say, "The bulb is lighted up". Look at the picture above those words. That picture above those words shows the bulb lighted up.

Now put your finger on the word with two blue lines under it. It is the word 'then'. Move your finger now to the words with one blue line under them. Those words are the then-part of our if-then sentence. They say, "The circuit is complete". The picture just above those words shows a battery with a long green arrow going all the way from one end of the battery to the other end. We can use that picture to mean a complete circuit.

Now you can read the if-then sentence using the pictures; or if you know the words, you can read them.

Point to each part of the if-then sentence as you whisper it with me, now. [Whisper...] If the bulb is lighted up, then the circuit is complete. Let's try that once more. [Whisper again.]

There is a small yellow box up on the shelf. Move that yellow box to the table beside the folder with the if-then sentence on it.

Now we are going to talk about what you can figure out from that true if-then sentence.

You know that sometimes you can figure out whether one part of an if-then sentence is true or false by observing or being told whether the other part is true or false. But sometimes you cannot figure out whether one part is true or false by observing whether the other part is true or false. When the if-part is true, you can figure out that the then-part must be true.

Now, let's pretend that the if-part of the if-then sentence in the folder is true. Find the yellow card in the small, yellow box that shows the bulb lighted up. Put that yellow card on the folder under the if-then sentence. The picture on the yellow card shows that the if-part is true, doesn't it?

Can you figure out whether the then-part would be true or false when the if-part is true? Push a lever to answer whether the then-part (that says the circuit is complete) would be true or false, or push both levers if you don't know enough to figure out whether the then-part would be true or false. [Pause.]

It would be true, wouldn't it? You can figure out that the then-part would be true because the if-part is true. The circuit has to be complete if the bulb is lighted up. There has to be a path for electricity to go around, to make the bulb light up.

Now put that yellow card back in the yellow box and take out the other yellow card. The one that shows the bulb not lighted up. Now put that yellow card down on the folder under the if-then sentence.

You have heard before that when the if-part is false, you can't figure out whether the then-part is true or false. You have to find out some other way.

Now let's pretend that the if-part of the if-then sentence in the folder is false as it says and shows on the yellow card on the folder. Push a lever to answer whether the then-part would be true or false, or push both levers if you don't know enough to figure out whether it would be true or false. Push a lever or levers, now. [Pause.]

You don't know enough to figure out whether the then-part would be true or false. You should have pushed both levers. When the if-part is false, the then-part might be true or it might be false. Even though the bulb is not lighted up, there may be a complete circuit. There could be a different path for electricity to go around so that it couldn't go to the bulb.

Take the red piece of wire out of the white box. Now put one end of that red piece of wire right on the little, round silver colored part on the end of the battery. Touch the other end of the wire to the metal bottom part of the battery.

Did the bulb light up? It didn't light up, but the circuit was complete. The electricity could go from the battery through the red wire to the other end of the battery. Be sure to take the wire away from the battery now. If you held it there very long, the battery would run down.

When the electricity goes through a complete circuit of just a wire, we say that there is a 'short circuit'. You may remember having a short circuit at home and having a fuse blow.

Put the wire down now and put the yellow card back in the yellow box.

You have learned two rules about what you can figure out when you know about the if-part of an if-then sentence.

The first rule says: If you know that the if-part is true, then you can figure out that the then-part must be true, also.

The second rule says: If you know that the if-part is false, you cannot figure out whether the then-part is true or false.

You have had a lot of thinking to do today, haven't you? We will talk about these things again another day.

Now it's time to get the booth ready for the next person.

Put the yellow box back on the shelf.

Now put the wire and the battery into the white box. Put the white box back under the shelf.

Now close the folder with the if-then sentence in it and put it back under the shelf.

Now it's time to rewind the tape recorder. Remember, first you push the red stop button, then the yellow rewind button. When you see and hear the little wheels stop turning, push the red stop button again.

Push the red stop button, now.

[Repeat from, "Remember,...."]

Content and Materials for the Lessons

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
I	In Science we do things to find out about the world and things around us. There are different kinds of energy. Things that make other things warmer give off heat energy. Things that make light give off light energy. Things that are moving have kinetic energy.	When we tell something about a thing, we make a statement about that thing. Statements can be true or not true. We say that statements that are not true are false. (Preliminary: Two of the ways to find out if a statement is true or false are to look and see and to touch.)	Word science on table, printed in black with blue line under it - star at beginning of line. Tan box with blue car in it ("hill" in box slanted so that car rolls down slowly). Folder about energy - word energy in red letters on cover. Under energy - (small) pictures of burning wood, airplane, sun shining over house, girl pressing blue kerchief, boy riding bicycle. Inside folder - (large) picture of children playing on slide and swings. Light bulb and socket with pull chain. Headphones, tape recorder.
II	Things that have energy can give energy to other things. One thing that has kinetic energy can give some of its kinetic energy to another thing. One thing can give some of its heat energy to another thing.	There are many ways to find out whether a statement is true or false. Two of the ways to find out if a statement is true or false are to look and see and to touch. When we look and see or touch to find out if a statement about a thing is true or false, we say that we observe that thing.	Word science on table. Gray film loop projector - blue arrow on knob - green go sign - red stop sign. Film loop - Beebe Lake, dam, water wheel, man batting ball. Light bulb, socket and chain (light bulb upright so that pans can be put on it). Green box (without cover). In the green box: at least five different kinds of cups and/or pans. Headphones, tape recorder.

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
III	Things that are moving have kinetic energy. Things that are making light are giving off light energy.	There are many ways to find out whether a statement is true or false. One way to find out whether a statement is true or false without observing is to figure out from other statements we already know are true. We do not always know whether a statement is true or false.	Word science on table. Yellow true and false box with T and F levers. Tan box with inside divided into two parts - brown and white. In box: seven square pieces of wood - blue on one side, yellow on other - four have KE (kinetic energy) on both sides, three have LE (light energy) and HE (heat energy) on both sides. Headphones, tape recorder.
IV	Some kinds of energy can be stored and used later. Squeezed springs have energy stored in them--spring energy. One kind of energy can be changed into a different kind of energy. Spring energy can be changed into kinetic energy.	Sometimes we know enough about a thing to be able to say that if one statement about it is true, then another statement about it must also be true.	Word science on table. "Spring" pusher. Green box with green car in it (no cover to box). Picture of green car on table (under plastic) in front of blue block of spring thing. True and false box with T and F levers. Black box with black car in it (no cover on box). Picture of black car on table (under plastic) in front of picture of green car.

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
V	Another kind of stored energy is gravity energy. If you raise a thing up and just let it go, it will fall toward the earth because the force of gravity pushes it. Everything on earth or near it is pulled toward earth by force of gravity. Things which are raised up have stored energy (stored gravity energy). Gravity energy can be changed to kinetic energy.	When we say that if one statement is true then another one must also be true, we call what we say an if-then sentence. An if-then sentence has two parts: One part says if something and the other part says then something. When the if-part of an if-then sentence is true, the then-part must also be true.	Word science on table. Globe. Yellow box with metal bottom (for magnets to adhere to) with pictures and objects in it as follows (box divided into 4/5 and 1/5). In large part: magnetic objects on their pictures--sailboat, domino, pan, pitcher (green). In smaller part: metal paper clip on its picture. Picture (on wall of booth) of hand holding sailboat (like magnetic object) over a metal paper clip. Axle and crank: frame - green, axle - wood color, crank - brown with red handle, lever - silver with black part where you push.
VI	Another kind of energy is electrical energy. Kinetic energy can be changed into electrical energy. Electrical energy can be changed to light energy, heat energy, and kinetic energy.	When the if-part of an if-then sentence is true, the then-part must be true.	Picture box - with pictures of brown hand generator. Silver knob has green arrows on it. Hand generator with a switch, motor and bulb. True and false box and T and F levers. Two pictures of hand generator mounted on yellow paper on metal (magnet-attractable) with white arrow (movable).
VII	[Test program; no new content.]		

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
VIII	Kinetic energy can be changed into heat energy by rubbing two things together, causing friction.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. But we must be careful. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false.	Word science on table. True-false box. Long, tan box with inclined plane inside. Toy car in box.
IX	Scientists believe that energy can come only from other kinds of energy. Scientists ask many questions. Knowing about energy helps them ask questions. When they see something that has or gives off energy they ask, "Where did that thing get its energy?" "What kind of energy did this energy come from?" We can ask these kinds of questions, too. From where does the energy come to run lamps, flat irons, record players, etc., in our homes? Gravity energy stored in water changes into kinetic energy as the water falls. The falling water gives some of its kinetic energy to the water wheels in big electrical generators. The kinetic energy is changed into electrical energy in the generators. The electrical energy is changed into heat, light, and kinetic energy in our homes.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. But we must be careful. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false.	Picture box - with pictures of electrical appliances and the electric generating plant. Cardboard folder with: (a) blue numeral one in the front, (b) picture of hand generator connected to a bulb on the front, (c) yellow 'if' pocket inside containing picture about the if-part and a blue 'then' pocket containing a picture about the then-part. Cardboard folder with: (a) green numeral two on the cover, (b) yellow 'if' pocket containing a picture about the if-part (false) and a blue 'then' pocket containing two pictures about the then-part (one true and one false). True-false box.

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
X	A complete circuit is a path which electricity can go around and come back to where it started. A light bulb must be in a complete circuit in order to light up. Electrical energy changes into light energy in the wire inside a light bulb.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. But we must be careful. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false.	Word science on table. True-false box. White box with battery, blue wire fastened to light bulb, and red wire. Folder with 'If...then' sentence, "IF the bulb is lighted up, then the circuit is complete." Cardboard pocket with picture showing battery, wire and bulb connected in circuit. Yellow box with two cards in it, one with a lit bulb and captioned, "The bulb is lighted up"; one with an unlit bulb captioned, "The bulb is not lighted up."
XI	A complete circuit is a path which electricity can go around and come back to where it started. A light bulb must be in a complete circuit in order to light up. Electrical energy changes into light energy in the wire inside a light bulb.	When we have a true if-then sentence, we can tell that the if-part is false by finding out that the then-part is false. But again, we must be careful. If all we know is that then-part is true, we cannot figure out whether the if-part is true or false.	Word science on table. Folder with 'If...then' sentence, "IF the bulb is lighted up, then the circuit is complete." White box containing battery, red wire, and blue wire fastened to light bulb. Blue box with pocket in it. Pocket contains two cards, one showing a complete circuit through a battery and captioned, "The circuit is complete"; one with an incomplete circuit through a battery and captioned, "The circuit is not complete." True-false box.

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
XII	From where does the bulb in a complete circuit get its energy? When a battery is connected in a complete circuit, the chemicals in the battery change into different chemicals. When they change they give off electrical energy.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. But we must be careful. If all we know is that the then-part is true, we cannot figure out whether the if-part is true or false.	Green circuit board with battery-powered bulb, heating coil and motor. Contact for the bulb has a blue circle around it and a blue numeral one by it. That for the coil has a white circle and a white star; and that for the motor, a yellow circle and a yellow numeral three. Case of a used 'D' cell in a plastic box with a blue square on it, clear plastic bottle with the chemical from a used 'D' cell in it, and a blue cap on it, both in a blue box. Similar setup with a new 'D' cell labeled with yellow. True and false box.
XIII	Everything is made of chemicals. The chemicals in many things can change and give off energy. The chemicals in wood change when the wood burns and give off heat and light energy. The chemicals in wood have a kind of stored energy in them. We call the kind of energy that those chemicals have chemical energy. When When wood burns, the chemical energy stored in the chemicals in the wood changes into heat and light energy.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false. When we have a true if-then sentence, we can tell that the if-part is false by finding out that the then-part is false. But again, we must be careful. If all we know is that the then-part is true, we cannot figure out whether the if-part is true or false.	Word science on table. True-false box. Super-8 movie projector. Film loop. Picture of felled tree.

PROGRAM	SCIENCE CONTENT	LOGIC CONTENT	MATERIALS
XIV	From where does the wood get its stored chemical energy? The trees and other plants get energy to grow from sunlight. They use that light energy to make the chemicals wood is made of.	When we have a true if-then sentence, we can tell that the then-part is true by finding out that the if-part is true. If all we know is that the if-part is false, we cannot figure out for sure whether the then-part is true or false. When we have a true if-then sentence, we can tell that the if-part is false by finding out that the then-part is false. But again, we must be careful. If all we know is that the then-part is true, we cannot figure out whether the if-part is true or false.	Picture box with picture story about trees planted in adequate and inadequate sunlight. Cardboard folder containing sentence, "If the tree grew then it got enough light energy." Yellow box with two pictures in it, one showing the tree growing and one showing the tree not growing. Blue box with two pictures in it, one showing the sun shining and one showing the sun not shining. The true-false box.
XV	Electrical energy is changing into kinetic energy in this tape recorder. Electrical energy changes into light energy in the bulbs in the true-false box on the shelf. Chemical energy changes into electrical energy in the batteries in the true-false box. The wooden shelf and the paper folder in the booth have chemical energy stored in them. They can burn and change some of that chemical energy into heat and light energy.	When the then-part of one true if-then sentence is the if-part of another one, we can figure out that the then-part of the second one is true if we know that the if-part of the first one is true.	True-false box with front removed. Folder with two if-then sentences and picture inside. Top sentence: If one lever is pushed down all the way, then two bulbs are lighted up. Bottom sentence: If two bulbs are lighted up, then there is a complete circuit.

APPENDIX B

The Smith-Sturgeon Conditional Reasoning Test

I. The Basic Principles of Conditional Logic

II. Chemicals Part
Script
Discussion of Testing Instructions and Evaluation

III. House Part
Script
Discussion of Testing Instructions and Evaluation

IV. Evaluation Blanks for Scoring Each Question
Grade Sheet for the Chemicals Part
Grade Sheet for the House Part

This presentation of the Smith-Sturgeon Conditional Reasoning Test consists of a discussion of the basic principles of conditional logic, the script for each part of the test (chemicals part and house part), and a discussion of the evaluation procedures for each part of the test, organized as follows:

I. The Basic Principles of Conditional Logic.

II. Chemicals Part.
    A. Script.
    B. Discussion of Testing Instructions and Evaluation.

III. House Part.
    A. Script.
    B. Discussion of Testing Instructions and Evaluation.

IV. Evaluation Blanks for Scoring Each Question.

I. THE BASIC PRINCIPLES OF CONDITIONAL LOGIC

Five basic relationships in conditional logic are tested in this experiment. Each of these relationships is called a 'Principle'. Each Principle in turn, except for the first, is divided into a suppositional form, where one premise is imagined, and a factual form, where both premises are demonstrated through experiment and observation.

Principle I, Basic Understanding, serves as a sort of pretest to determine whether the subject is able to remember premises and engage in the simplest form of conditional reasoning, often called Modus Ponens. Here the subject, S, is shown that a particular antecedent, 'P', implies the consequent, 'Q'. He is then told that 'P' is true. If he is able to deduce the consequent, 'Q', he is said to have mastered Basic Understanding. If, on the other hand, he becomes confused even after these relationships are demonstrated concretely a number of times, or if he does not appear to believe that 'P' would always imply 'Q', the tester, T,must assume that S is not ready to be tested on more complex principles.

Principle II, or Inversion, is a fallacy principle. S learns that 'P' implies 'Q' and is then told that 'P' is not the case. The question, "Then, is 'Q' true?" must be answered "Maybe". S must realize that he cannot tell from the information 'P implies Q' and 'Not P' whether the appropriate response to 'Q?' is a definite yes or no.

Principle III, or Conversion, is also a fallacy principle and calls for a 'maybe' response. S is told that 'P implies Q' and is told that 'Q' is indeed true. The question is, "Does 'P' then have to be the case?" S, of course, needs additional information before he can answer a definite yes or no.

Principle IV, or Contraposition, is a validity principle. If S is told that 'P' implies 'Q' and is then told that 'Q' is not the case, he should respond that 'P' is also not the case.

Principle V, or Transitivity, is a kind of chain relationship: If P implies Q, and Q implies R, then the knowledge that P is the case leads directly to the conclusion that R also must be the case. To the question, "If you know that P implies Q and Q implies R, and P is true, is R true?", S must answer "yes".

In any concrete objects test there are problems both in assuring S's comprehension of the question asked and in the post-test evaluation of his answers. For each move covered in the script for the concrete objects test we have tried to define these problems along with our attempts to overcome them.

These principles are discussed in more detail and illustrated in Chapter 1 of the body of the report. The whole test is examined in Chapter 4.*

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*Robert H. Ennis, Mark R. Finkelstein, Edward L. Smith and Nancy H. Wilson, Conditional Logic and Children (Ithaca, N.Y.: Cornell Critical Thinking Project, 1969).

II. CHEMICALS PART: Script

Testing Instructions. Time: 40-60 minutes.

Materials needed (see illustration for the physical layout of the test).

25-30 small glass beakers.
Vinegar bottle.
Red bottle of baking soda.
Blue soap box of baking powder (marked with an X).
Yellow cannister of sugar (the chemical lactose).
Can of talc (marked with an X).
Alcohol.
6-10 medicine droppers.
3 shades of food coloring, for the liquids in the litmus test (see the diagram for where to put blue, red, green),
Metal bulletin board.
Signs (magnetic) representing soda, sugar, a bubbling substance (2), milky substance (2), as well as 2 plus signs and 2 arrows (should also have signs to illustrate the premises used in Transitivity, namely a picture of a liquid making soda bubble and one showing that liquid turning the litmus paper red).
Litmus paper.
Screen (self-supporting).
Table covered with plastic table cloth.*
2 aprons.*
5-10 spoons.

Notes:

Different sizes and shapes of containers are used as memory aids. (Subjects who have not seen soda can remember that it is in a red bottle.)

Primary colors are used wherever possible.

Signs and bulletin board are used both as memory aids and to help T evaluate S's understanding of premises.

A tape recorder allows T to recall S's exact words.

Preparation.

1. Five beakers containing small amounts of soda, sugar, sugar, soda, and baking powder are placed on the table in a line in

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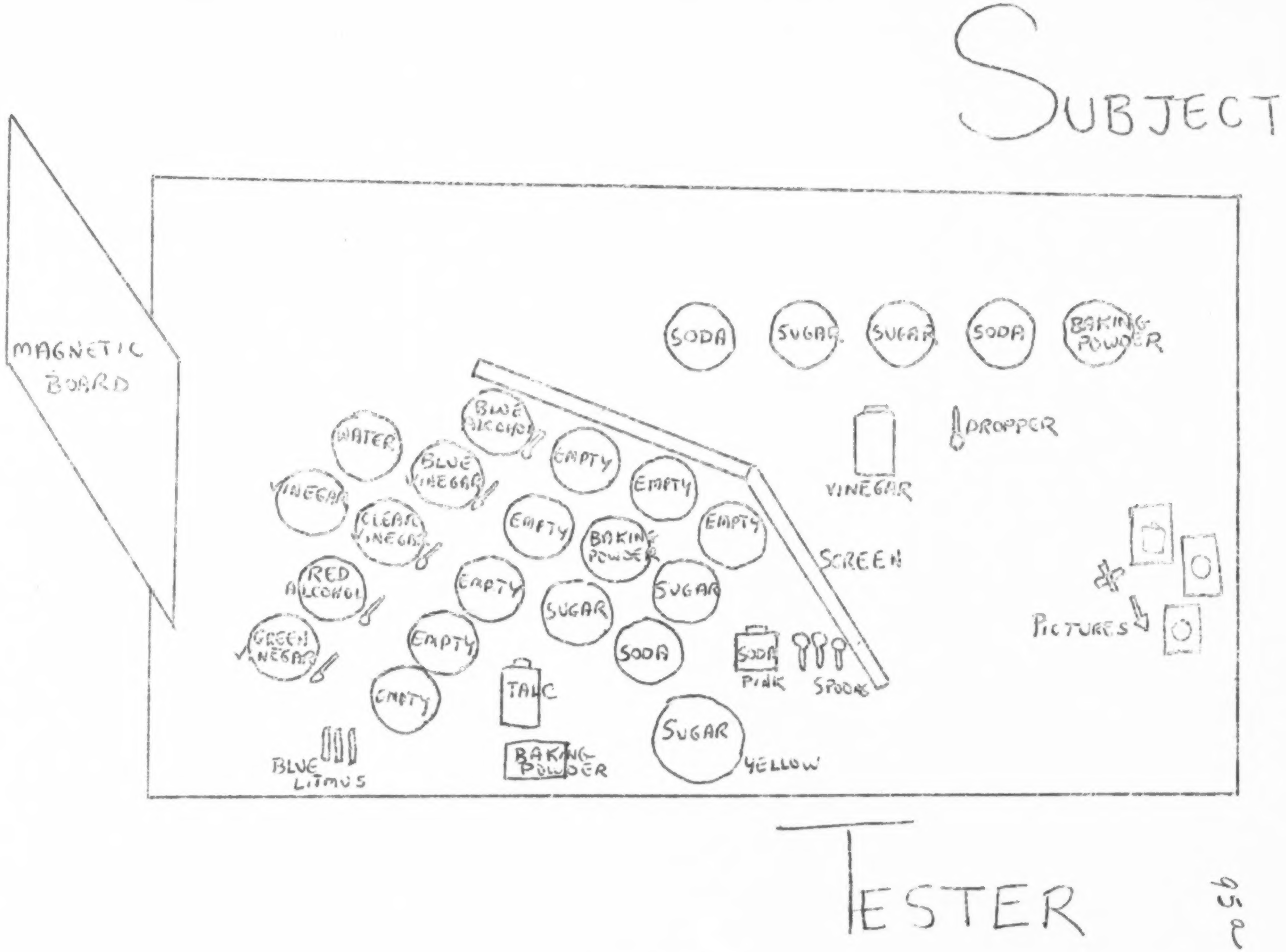
*Not essential.

CHEMICALS PART - Initial Physical Layout


SUBJECT
MAGNETIC BOARD
SODA
SUGAR
SUGAR
SODA
BAKING POWDER
DROPPER
VINEGAR
SCREEN
PICTURES
BLUE ALCOHOL
WATER
BLUE VINEGAR
EMPTY
EMPTY
EMPTY
VINEGAR
CLEAR VINEGAR
EMPTY
BAKING POWDER
RED ALCOHOL
EMPTY
SUGAR
SUGAR
GREEN VINEGAR
EMPTY
SODA
SODA
PINK
SPOONS
EMPTY
TALC
SUGAR
YELLOW
BLUE LITMUS
BAKING POWDER
TESTER

front of the subject. (This order is suggested so that the bubbling reactions are spread out.)

2. A bottle of vinegar and a dropper are placed within reach of T and S.

3. The metal bulletin board is placed against the wall at one end of the table.

4. Signs for the board are placed within reach of T along with 4-8 empty beakers.

5. Behind the screen are five colored liquids in beakers (3 vinegar, 2 alcohol) and at least six pieces of blue litmus paper. At least one color should be shared by alcohol and vinegar in order to focus the attention of the subject on the reaction of each liquid instead of on the appearance of the liquid. Beside each beaker of liquid is placed a medicine dropper and an empty beaker. (In this group there are 10 beakers in all.)

6. Two more lines of three beakers each are placed behind the screen. In the first line of beakers are soda, sugar, and an empty beaker, in that order. In the second line are sugar, baking powder and an empty beaker.

7. Also behind the screen are the spoons, the can of talc, the containers of soda, sugar, and baking powder.

8. A beaker of water and a beaker of vinegar may be prepared and placed behind the screen for demonstrating the behavior of litmus paper.

9. SCRIPT:
   All capitalized words - what Tester (T) says.
   Brackets - what Tester does.
   Quotations ("....") - possible responses of Subject (S).

Notes:

Time required is about 10 minutes if water source is nearby.

Amounts in the beakers should be large enough to see but small enough so that the powdery substances are difficult to tell apart.

Another acid (lemon juice) could be substituted for vinegar among the colored liquids behind the screen. Vinegar was thought to be more economical and satisfactory as long as alcohol was used for the two non-acidic liquids to camouflage the vinegar smell.

At least one of the acidic solutions should be colored blue in order to convince S that litmus paper doesn't change color because of the dye in the liquid tested.

T should have extra beakers available.

Introduction.

TODAY WE ARE GOING TO DO SOME SCIENCE EXPERIMENTS. SEE HOW CAREFULLY YOU CAN WATCH WHAT IS HAPPENING. THEN I WILL ASK YOU SOME QUESTIONS; I WILL ALSO ASK YOU TO GIVE ME REASONS OR TELL ME HOW YOU FIGURED OUT THE ANSWERS YOU HAVE GIVEN. SO DON'T BE SURPRISED OR THINK YOUR ANSWER IS WRONG WHEN I SAY, "ARE YOU SURE OF THAT ANSWER?" OR "HOW DID YOU DECIDE THAT?" NOW, SOME OF THE QUESTIONS YOU CAN FIGURE OUT AN ANSWER FOR, BUT SOME QUESTIONS YOU WILL NOT HAVE ENOUGH INFORMATION TO ANSWER. IF YOU DON'T KNOW ENOUGH TO FIGURE OUT AN ANSWER, DON'T TRY TO GUESS. JUST SAY, "I CAN'T TELL" OR "I DON'T KNOW" AND SEE IF YOU CAN SAY WHY YOU CAN'T TELL. ARE YOU READY TO BEGIN? REMEMBER THAT MAYBE OR I DON'T KNOW IS THE RIGHT ANSWER SOMETIMES, AND SOMETIMES YES OR NO IS THE RIGHT ANSWER.

Acquaintance With Materials and Awareness of Major Premise.

Introduction of Major Premise - Basic Understanding.

1. IN FRONT OF YOU ARE SOME JARS OF WHITE STUFF. SOME OF THEM ARE ALIKE. SOME OF THEM ARE DIFFERENT. THERE ALSO MIGHT BE JARS OF WHITE STUFF BEHIND THE SCREEN THAT ARE DIFFERENT YET.

2. CAN YOU TELL WHAT THESE KINDS OF WHITE STUFF ARE? [You may substitute the word "powder" for white stuff if you think the child understands the word as a general term.]
   a) "No." YES, WE CAN'T TELL FOR SURE, CAN WE, SO THEN WE SAY, "I DON'T KNOW."
   b) "Yes." HOW CAN YOU TELL? ARE YOU SURE? PERHAPS IT IS SOME POWDER

WE HAVE NEVER SEEN BEFORE AND SO WE CAN'T KNOW FOR SURE AND MUST SAY, "I CAN'T TELL." [Ask him if he is sure. Encourage him to say he can't know for sure, but if necessary tell him and explain why.]

3. HERE IS A BOTTLE OF VINEGAR. HAVE YOU EVER SEEN VINEGAR BEFORE?

4. PUT A DROPPERFUL OF VINEGAR INTO EACH CUP WITH POWDER IN IT, AND WATCH TO SEE WHAT HAPPENS. WHEN YOU SEE WHAT HAPPENS, TELL ME WHAT YOU SEE. [_T_ encourages _S_ to describe the reaction he sees after vinegar is added to the powder in each beaker. _T_ should not rush ahead, but should allow _S_ to describe each reaction fully. _S_ should notice that the vinegar turns white and doesn't bubble in the case of the sugar, but bubbles when it is added to soda and baking powder. All this is observed, of course, without _S_'s knowledge of the identity of any of the substances.]

5. DID ANY OF THE WHITE STUFF BUBBLE OR FIZZ WHEN YOU ADDED THE VINEGAR? "Yes." WHICH ONES?

6. DID ANY OF THE WHITE STUFF TURN A MILKY COLOR AND NOT BUBBLE? "Yes." WHICH ONES?

7. DID YOU SEE ANYTHING ELSE HAPPEN? [_T_ removes the five beakers out of _S_'s reach.]

8. YOU HAVE DONE VERY WELL IN TESTING THE WHITE STUFF THAT YOU DON'T KNOW. NOW WE'LL TEST A WHITE STUFF FROM A BOTTLE THAT YOU'LL SEE. THE NAME OF THIS WHITE STUFF IS SODA. [_T_ takes red soda bottle from behind

screen.]

9. HAVE YOU EVER SEEN SODA BEFORE? IF YOU CAN'T REMEMBER THE NAME, JUST REMEMBER THAT IT'S THE WHITE STUFF FROM THIS RED BOTTLE.

10. [T puts an empty beaker in front of S.] POUR A LITTLE WHITE STUFF FROM THE RED BOTTLE INTO THIS JAR. DO YOU KNOW WHAT WILL HAPPEN TO IT IF YOU ADD VINEGAR?
    a) "No." RIGHT, WE DON'T KNOW.
    b) "Yes." CAN WE REALLY KNOW FOR SURE? [Encourage S to say he doesn't know.]

11. NOW LET'S TRY IT. PUT SOME VINEGAR IN THIS DROPPER AND ADD IT TO THE SODA IN THE JAR IN FRONT OF YOU. WHAT IS HAPPENING? "Bubbling."

12. COULD YOU TELL ME WHAT WILL HAPPEN IF I TAKE SOME MORE SODA FROM THE RED BOTTLE AND ADD VINEGAR TO IT? ARE YOU SURE?
    a) "It will bubble." ARE YOU SURE? [If "yes", then go to #13. T does not try to encourage skepticism on S's part; the point here is to convince S as quickly as possible that the major premise is always true because T tells him, not because he sees it happen. The observation is only to impress him and help him remember T's statement.]
    b) "Will not bubble" or "I'm not certain". [Using another empty beaker repeat the experiment. If, after 3 or 4 repetitions of the procedure in 12, S is still unable to say that soda will always bubble if vinegar is added to it, stop the test.]

13. YES, WHENEVER WE ADD VINEGAR TO SODA THE VINEGAR WILL MAKE THE SODA BUBBLE.

14. [Show the red bottle to S.] IS THIS SODA? "Yes." WILL VINEGAR MAKE THIS SODA BUBBLE? "Yes." ARE YOU SURE? "Yes." TRY IT. [Watches S do it.] VERY GOOD.

15. LET'S PUT SOME PICTURES UP ON THE BOARD TO HELP YOU REMEMBER WHAT YOU FOUND OUT.

16. FIND THE PICTURE OF THE SODA BOTTLE. [S puts it on the board.]

17. WHAT DOES THIS SIGN MEAN? "Add." [S puts it on the board.]

18. WHAT DID WE ADD TO SODA? "Vinegar." [S finds the picture and puts it on the board.]

19. THIS ARROW POINTS TO WHAT HAPPENED. [S puts on board.]

20. FIND THE PICTURE THAT SHOWS WHAT HAPPENED. WHY DID YOU CHOOSE THAT ONE? "Because soda bubbles." [S puts this on the board. Review.] SODA WITH VINEGAR ADDED BUBBLES.

Conversion - Suppositional Form.

21. DO YOU KNOW WHAT IT MEANS TO PRETEND SOMETHING? [If S seems confused, T explains. T holds up an empty beaker.]

22. PRETEND THAT THERE IS SOME DRY, WHITE STUFF IN THIS JAR; WE ADDED VINEGAR, AND IT BUBBLED. WHAT ARE WE PRETENDING? [T repeats as often

as necessary. If unsuccessful at getting S to understand, then skip to the next set of questions, i.e., #27.]

23. NOW DO YOU REMEMBER WHAT VINEGAR DID TO SODA? "It made it bubble." [Point to board if S doesn't recall.]

24. IF SOME WHITE STUFF IN THIS JAR BUBBLED WHEN VINEGAR WAS ADDED TO IT, WOULD YOU SAY IT IS SODA, IT IS NOT SODA, OR MAYBE IT IS AND MAYBE IT ISN'T SODA? [If a 'maybe' answer is chosen, T must make sure that S means both maybe it is and maybe it isn't.]

25. ARE YOU SURE OF THAT ANSWER? I DON'T CARE WHAT ANSWER YOU GIVE; JUST TAKE YOUR TIME AND THEN SETTLE ON AN ANSWER YOU ARE SURE OF.
a) "Yes." [Go to #26.]
b) "No." WHY AREN'T YOU SURE?

26. HOW DID YOU DECIDE THAT? [If S seems unable to justify his answer, say, DO YOU REMEMBER FOR SURE WHAT WE'RE PRETENDING? YES, NOW IF THIS STUFF DID BUBBLE WHEN WE ADDED VINEGAR TO IT, DID YOU SAY IT WOULD BE THE SODA, IT WOULDN'T BE SODA, OR YOU CAN'T BE SURE IF IT'S SODA OR NOT? I SEE.... WHY DID YOU CHOOSE THAT ANSWER? Pause to give S time to think, but if he still can't give a reason for his answer, move on.]

Conversion - Factual Form.

27. NOW I'LL SHOW YOU THE POWDER WE'RE GOING TO TEST. [T takes beaker of soda from behind the screen--first beaker in the first line of three.] CAN YOU TELL WHAT IT IS FOR SURE BY LOOKING AT IT? WHAT DO WE KNOW

HAPPENS WHEN WE ADD VINEGAR TO SODA?

28. ADD A DROPPER OF VINEGAR TO THIS POWDER AND TELL WHAT YOU SEE HAPPENING.

29. [T pauses to let S tell him.] YES, IT IS BUBBLING.

30. WOULD YOU SAY THAT THIS IS THE SODA FROM THE RED BOTTLE FOR SURE, THAT IT IS NOT, OR WOULD YOU SAY THAT YOU CAN'T BE SURE: MAYBE IT IS AND MAYBE IT ISN'T. [If these alternatives seem to confuse S, say: YOU HAVE THREE ANSWERS TO CHOOSE FROM. YES, THIS IS SODA. NO, THIS IS NOT SODA. OR, MAYBE.]

31. ARE YOU SURE OF THAT ANSWER?
    a) "Yes." [Go to #32.]
    b) "No." WHY AREN'T YOU SURE?

32. HOW DID YOU DECIDE THAT?

Contraposition - Suppositional Form.

33. [T holds up an empty beaker.] PRETEND THIS TIME THAT THERE IS SOME WHITE STUFF IN THIS JAR WHICH DOES NOT BUBBLE WHEN WE ADD VINEGAR TO IT. WHAT ARE YOU PRETENDING? [T may repeat as often as necessary.]

34. WHAT DID THE VINEGAR DO TO THE SODA? [Point to the board.] YES, IT MADE THE SODA BUBBLE.

35. NOW IF THIS WHITE STUFF DID NOT BUBBLE WHEN WE ADDED VINEGAR TO IT, WOULD YOU SAY IT IS SODA, IT IS NOT SODA, OR MAYBE IT IS, MAYBE IT ISN'T?

36. ARE YOU SURE OF THAT ANSWER?

a) "Yes." [Go to #37.]

b) "No." WHY AREN'T YOU SURE.

37. HOW DID YOU DECIDE THAT? [T may probe further, using the suggestions in #26.]

Contraposition - Factual Form.

38. NOW ONCE AGAIN, WHAT HAPPENED WHEN WE ADDED VINEGAR TO SODA? "It bubbled." [T takes beaker with sugar in it from behind the screen. This should be the second beaker in the first line of three.] HERE IS ANOTHER POWDER FOR YOU TO TEST. CAN YOU TELL FOR SURE WHAT IT IS BY LOOKING AT IT? [If S answers 'yes', T asks why and tries to persuade him that he has no real way of knowing what the powder is.] IT COULD BE ONE OF MANY DIFFERENT POWDERS. WE CAN'T REALLY TELL WHICH POWDER IT IS JUST BY LOOKING. DO YOU THINK IT MIGHT BE SODA?

a) "Yes." [Go to #39.]

b) "No." [T might try getting another beaker from behind the screen in which the amount of sugar is less, and should ask the same questions about the 'new' powder. Or say: SINCE WE CAN'T TELL FOR SURE WHAT THIS POWDER IS, THERE IS A CHANCE THAT IT MIGHT BE SODA, BUT ALSO THAT IT MIGHT NOT BE SODA.]

39. NOW ADD A DROPPER OF VINEGAR TO THIS WHITE STUFF. WHAT IS HAPPENING? "Turns white."

40. [T points to soda bottle on board.] WOULD YOU SAY THAT THE POWDER YOU

JUST TESTED IS SODA FROM THE PINK BOTTLE, IS NOT SODA, OR MAYBE IT IS SODA, MAYBE NOT? "Is not."

41. ARE YOU SURE OF THAT ANSWER?
    a) "Yes." [Go to #42.]
    b) "No." WHY AREN'T YOU SURE?

42. HOW DID YOU DECIDE THAT? [If S says that the substance is soda, repeat #38 with another beaker of sugar and insert, WHAT DO WE KNOW WOULD HAVE TO HAPPEN IF THIS WERE SODA AND WE ADDED VINEGAR TO IT? between #38 and #39. T should be casual as S should not realize that this is repetition.]

Inversion - Suppositional Form.

43. PRETEND THIS TIME THAT I GAVE YOU SOME WHITE STUFF AND TOLD YOU IT WAS NOT SODA. WHAT ARE YOU PRETENDING?

44. WHAT DID SODA DO WHEN WE ADDED VINEGAR TO IT? "Bubbled."

45. IF THIS WHITE STUFF WAS NOT SODA, WOULD YOU SAY THAT IT WOULD BUBBLE IF WE ADDED VINEGAR TO IT, IT WOULD NOT BUBBLE SINCE IT ISN'T SODA, OR IT MIGHT BUBBLE AND IT MIGHT NOT? "Maybe."

46. WOULD YOU BE SURE OF THAT ANSWER?
    a) "Yes." [Go to #47.]
    b) "No." WHY AREN'T YOU SURE?

47. HOW DID YOU DECIDE THAT?

Inversion - Factual Form.

48. AGAIN NOW, WHAT DO WE KNOW HAPPENS WHEN WE ADD VINEGAR TO SODA? [T takes empty beaker from behind the screen along with the blue baking powder box.] HERE IS A POWDER AND I'LL TELL YOU SOMETHING ABOUT IT. THIS SUBSTANCE IS NOT SODA.

49. IF YOU ADDED VINEGAR TO IT, WOULD YOU SAY IT WILL BUBBLE AS THE SODA DID, IT WON'T BUBBLE SINCE IT ISN'T SODA, OR IT MIGHT BUBBLE AND IT MIGHT NOT? "Might and might not."

50. ARE YOU SURE OF THAT?

a) "Yes." [Go to #49.]

b) "No." WHY AREN'T YOU SURE?

51. WHY DID YOU CHOOSE THAT ANSWER?

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Introduction of Major Premise - Basic Understanding.

52. WE'LL PUT SOME OF THESE POWDERS AWAY NOW AND GET OUT A NEW POWDER FOR YOU TO TEST. [T takes yellow sugar box from behind the screen.]

53. THIS POWDER IS CALLED SUGAR AND COMES FROM THIS YELLOW BOX. WHAT DO YOU KNOW ABOUT SUGAR? DO YOU KNOW WHAT WILL HAPPEN TO SUGAR WHEN WE ADD VINEGAR TO IT?

54. USE THIS CLEAN SPOON AND PUT A LITTLE SUGAR INTO THIS EMPTY JAR. NOW ADD THE VINEGAR IN THIS DROPPER AND TELL ME WHAT YOU SEE. "Does not

bubble and turns the vinegar a whitish color." [If air bubbles appear in the beaker, _T_ points out this is _not_ the foamy bubbling of vinegar and soda.]

55. COULD YOU TELL ME WHAT WILL HAPPEN IF I TAKE SOME MORE SUGAR FROM THE YELLOW BOX AND ADD VINEGAR TO IT? "No bubbles, a white color." WOULD YOU BE SURE? [A correct prediction and an affirmative answer to 'are you sure?' are crucial to the continuation of the experiment. Impress upon the subject that the same reaction will _always_ occur no matter how many times it is tried. Stop here and go to the 'transitivity' experiment (#94) if _S_ in your judgment fails to grasp Basic Principle.]

56. YES, WHENEVER WE ADD VINEGAR TO SUGAR, THE VINEGAR WILL MAKE THE SUGAR TURN WHITE BUT NOT BUBBLE (foam, or fizz).

57. [_T_ shows the yellow box to _S_.] IS THIS SUGAR? "Yes." WILL VINEGAR MAKE THIS SUGAR TURN WHITE AND NOT BUBBLE? "Yes." ARE YOU SURE? LET'S DO IT ANYWAY.

58. LET'S PUT SOME PICTURES UP ON THE BOARD TO HELP YOU REMEMBER WHAT YOU FOUND OUT.

59. FIND THE PICTURE OF THE SUGAR BOX.

60. WHAT DOES THIS SIGN MEAN? "Add."

61. WHAT DID WE ADD TO SUGAR? "Vinegar."

62. THIS ARROW POINTS TO WHAT HAPPENED.

63. FIND THE PICTURE THAT SHOWS WHAT HAPPENED. WHY DID YOU CHOOSE THAT ONE? "Sugar turns white and does not bubble."

Conversion - Suppositional Form.

64. [T holds up an empty beaker.] PRETEND THAT THERE IS SOME DRY, WHITE STUFF IN THIS JAR; WE ADD VINEGAR, AND IT TURNS WHITE AND DOESN'T BUBBLE. WHAT ARE WE PRETENDING? [T repeats as often as necessary to make certain this is understood.]

65. NOW DO YOU REMEMBER WHAT VINEGAR DID TO SUGAR? [Points to board.] "Turned white and did not bubble."

66. IF SOME WHITE STUFF IN THIS JAR DID NOT BUBBLE AND TURNED THE VINEGAR WHITE WHEN WE ADDED VINEGAR TO IT, WOULD YOU SAY IT IS SUGAR, IT IS NOT SUGAR, OR MAYBE IT IS AND MAYBE IT ISN'T SUGAR? [If 'maybe' answer is chosen, T must make sure that S means both 'maybe it is' and 'maybe it isn't'.]

67. ARE YOU SURE OF THAT ANSWER?
    a) "Yes." [Go to #68.]
    b) "No." WHY AREN'T YOU SURE?

68. HOW DID YOU DECIDE THAT? [If S seems unable to justify his answer, say, DO YOU REMEMBER FOR SURE WHAT WE'RE PRETENDING? Then repeat possible answers and when one is chosen, say, I SEE.... WHY DID YOU CHOOSE THAT ANSWER? Pause...but move on if S still can't give a reason.]

Conversion - Factual Form.

69. NOW I'LL SHOW YOU THE POWDER WE'RE GOING TO TEST. [T takes beaker with a little sugar in it from behind the screen. This should be the first beaker in the second line of three.]

70. ADD A DROPPER OF VINEGAR TO THIS POWDER AND TELL ME WHAT YOU SEE HAPPENING.

71. [T pauses to let S tell him.] YES, IT IS NOT BUBBLING, AND IT IS TURNING WHITE.

72. WOULD YOU SAY THAT THIS IS THE SUGAR FROM THE YELLOW BOX FOR SURE, THAT IT IS NOT SUGAR FOR SURE, OR WOULD YOU SAY THAT YOU CAN'T BE SURE: MAYBE IT IS, MAYBE IT ISN'T?
a) "Yes." [Continue.]
b) "No." WHY AREN'T YOU SURE?

73. ARE YOU SURE OF THAT ANSWER?

74. HOW DID YOU DECIDE THAT?

Contraposition - Suppositional Form.

75. [T holds up an empty beaker.] PRETEND THIS TIME THAT THERE IS SOME WHITE STUFF IN THIS JAR WHICH DOES BUBBLE WHEN WE ADD VINEGAR TO IT. WHAT ARE YOU PRETENDING? [T may repeat as often as necessary to be certain it is understood.]

76. DO YOU REMEMBER WHAT THE VINEGAR DID TO THE SUGAR? [Point to the board.] YES, IT MADE THE SUGAR TURN MILKY AND NOT BUBBLE.

77. NOW IF SOME WHITE STUFF IN THIS JAR DID BUBBLE WHEN WE ADDED VINEGAR TO IT, WOULD YOU SAY IT IS SUGAR, IT IS NOT SUGAR, OR MAYBE IT IS AND MAYBE IT ISN'T? "Not sugar." [Correct answer.]

78. ARE YOU SURE OF THAT ANSWER?
   a) "Yes." [Continue.]
   b) "No." WHY AREN'T YOU SURE?

79. HOW DID YOU DECIDE THAT?

Contraposition - Factual Form.

80. [T takes beaker with baking powder in it from behind the screen, beaker #2 in line #2.] HERE IS A POWDER FOR YOU TO TEST. CAN YOU TELL FOR SURE WHAT IT IS BY LOOKING AT IT? "No." [If S answers 'yes', T asks why and tries to persuade him that he has no real way of knowing what the powder is.] DO YOU THINK IT MIGHT BE SUGAR?
   a) "Yes."
   b) "No." THERE ARE MANY WHITE POWDERS, SUCH AS FLOUR, IN THE WORLD AND WE REALLY CAN'T TELL FOR SURE WHICH THIS IS JUST BY LOOKING AT IT. SINCE WE CAN'T TELL FOR SURE, THERE IS A CHANCE THAT THIS POWDER MIGHT BE SUGAR, AND IT MIGHT NOT BE SUGAR. DO YOU AGREE? "Yes."

81. NOW ADD A DROPPER OF VINEGAR TO THIS WHITE STUFF. WHAT IS HAPPENING?

"Bubbles."

82. [T̲ points to sugar box on board.] WOULD YOU SAY THAT THE POWDER YOU JUST TESTED IS SUGAR FROM THE YELLOW BOX, IS NOT SUGAR, OR MAYBE IT'S SUGAR AND MAYBE IT'S NOT? "Is not."

83. ARE YOU SURE OF THAT ANSWER?

a) "Yes." [Continue.]

b) "No." WHY AREN'T YOU SURE?

84. HOW DID YOU DECIDE THAT? [If S̲ says that the substance is sugar, assume that he is confused, and repeat experiment, making sure that the reaction of sugar and vinegar is reviewed first.]

Inversion - Suppositional Form.

85. PRETEND THIS TIME THAT I GAVE YOU SOME WHITE STUFF AND TOLD YOU IT WASN'T SUGAR. WHAT ARE YOU PRETENDING?

86. WHAT DID THE SUGAR DO WHEN WE ADDED VINEGAR TO IT? "Turned white, no bubbles."

87. IF THIS WHITE STUFF WAS NOT SUGAR, WOULD YOU SAY THAT IT WOULD TURN THE VINEGAR SORT OF WHITE AND NOT BUBBLE, THAT IT WOULD HAVE TO DO SOMETHING DIFFERENT SINCE IT WASN'T SUGAR, OR IT MIGHT ACT LIKE THE SUGAR AND IT MIGHT NOT? "Might act the same or it might act different."

88. WOULD YOU BE SURE OF THAT ANSWER?

89. HOW DID YOU DECIDE THAT?

Inversion - Factual Form.

90. [T takes empty beaker from behind the screen, 3rd in 2nd line, and the can of talc.] HERE IS A POWDER WHICH IS NOT SUGAR.

91. YOU WILL BE ADDING SOME VINEGAR TO IT. WOULD YOU SAY IT WILL TURN WHITE AND NOT BUBBLE AS THE SUGAR DID; IT WILL HAVE TO DO SOMETHING ELSE SINCE IT ISN'T SUGAR, OR MAYBE IT WILL ACT LIKE THE SUGAR AND MAYBE IT WON'T? "Maybe."

92. ARE YOU SURE OF THAT ANSWER?

a) "Yes." [Continue.]

b) "No." WHY AREN'T YOU SURE OF THAT?

93. HOW DID YOU DECIDE THAT?

[Pause for a rest if necessary.]

Transitivity - Suppositional Form.

94. [T takes the five colored liquids, the five droppers, the five empty beakers, and the red bottle of soda from behind the screen and lines them up in front of the subject. Each beaker of liquid should have a dropper and an empty beaker beside it.] NOW WE'LL GET READY TO TEST SOME LIQUIDS. DO YOU KNOW WHAT A LIQUID IS? "Yes...." YES, A LIQUID IS A JUICE OF SOME KIND.

95. YOU ALREADY KNOW WHAT ONE LIQUID WILL DO IF WE ADD IT TO SODA. VINEGAR IS A LIQUID. WHAT DOES VINEGAR MAKE SODA DO? "Bubble."

96. YES, WHEN WE ADD VINEGAR TO SODA, IT MAKES THE SODA BUBBLE.

97. NOW WE WILL PUT A LITTLE SODA IN EACH OF THESE EMPTY BEAKERS AND SEE WHAT THESE LIQUIDS WILL MAKE THE SODA DO.

98. TAKE THE DROPPER BESIDE EACH PAIR OF JARS AND PUT SOME OF EACH LIQUID INTO THE JAR OF SODA BESIDE IT. IF THE LIQUID MAKES THE SODA BUBBLE LIKE THE VINEGAR DID WHEN YOU ADDED IT TO SODA, LEAVE THE TWO JARS IN FRONT OF YOU. IF THE LIQUID DOES NOT MAKE THE SODA BUBBLE, MOVE IT AND THE SODA OVER TO THE SIDE OF THE TABLE. DO YOU UNDERSTAND WHAT TO DO? [Clarify if necessary.]

99. NOW BEGIN BY ADDING THE LIQUID IN THE FIRST JAR TO THE SODA BESIDE IT. DID IT MAKE THE SODA BUBBLE? WHAT SHOULD YOU DO WITH THE JARS?

100. [T pauses while S repeats process for each pair of beakers.]

101. HOW ARE ALL THE LIQUIDS THAT YOU HAVE LEFT IN FRONT OF YOU ALIKE? WHAT DID THEY DO TO THE SODA? "Made it bubble."

102. YES, ALL OF THESE LIQUIDS MADE THE SODA BUBBLE.

103. NOW WE'LL TEST THE LIQUIDS THAT MADE SODA BUBBLE IN ANOTHER WAY.

104. [T takes out litmus paper.] HAVE YOU EVER SEEN PAPER LIKE THIS BEFORE? SOMETIMES IT JUST GETS WET WHEN YOU DIP IT INTO A LIQUID. [Demonstrate --put into a beaker of water.] SOMETIMES IT CHANGES COLOR. [Demonstrate--put into a beaker of vinegar.]

105. YOU ARE GOING TO TEST EACH OF THE LIQUIDS IN FRONT OF YOU WITH A PIECE OF BLUE PAPER. SEE IF THE PAPER STAYS THE SAME, LIKE THIS, OR CHANGES COLOR, LIKE THIS.

106. FIRST, DO YOU REMEMBER WHAT THIS LIQUID DID WHEN IT WAS ADDED TO THE SODA? YES, IT BUBBLED. WHAT DO YOU THINK IT WILL DO TO THE PAPER? [_T_ gives _S_ the paper.] TRY IT. WHAT HAPPENED? "Turns the paper red."

107. HERE IS THE SECOND LIQUID. WHAT DID IT DO WHEN IT WAS ADDED TO SODA? "It bubbled." WHAT DO YOU THINK IT WILL DO TO THE PAPER? "Turn the paper red", or "change color". TRY IT.

108. [Repeat.]

109. YES, IF A LIQUID MAKES SODA BUBBLE, IT WILL ALWAYS MAKE BLUE PAPER LIKE THIS CHANGE COLOR.

110.* IF YOU KNOW A LIQUID IS VINEGAR AND YOU ADD IT TO SODA, WHAT WILL HAPPEN? "It will bubble."

111.* YES, VINEGAR WILL MAKE SODA BUBBLE.

112.* IF YOU KNOW SOMETHING MAKES SODA BUBBLE, WHAT WILL IT DO TO THE BLUE PAPER? "The blue paper changes color."

113. YES, IT MAKES THE PAPER CHANGE COLOR. [Remove beakers.]

114. NOW PRETEND YOU TESTED SOME VINEGAR WITH THIS BLUE PAPER. WHAT ARE YOU PRETENDING?

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*Establish this clearly.

115. WOULD YOU SAY THAT IT WOULD MAKE THE PAPER CHANGE COLOR, OR THAT IT WOULD NOT MAKE THE PAPER CHANGE COLOR, OR WOULD YOU SAY MAYBE IT WOULD AND MAYBE IT WOULD NOT? "Change color." [Correct answer.]

116. ARE YOU SURE?

a) "Yes." [Continue.]

b) "No." WHY AREN'T YOU SURE?

117. HOW DID YOU DECIDE THAT?

Transitivity - Factual Form.

118. IS THIS VINEGAR? [T holds up bottle.]

119. WHAT DOES THIS VINEGAR MAKE SODA DO? "Bubble."

120. IF YOU TEST IT WITH THIS PAPER, WILL IT MAKE THE BLUE PAPER CHANGE COLOR, WILL THE BLUE PAPER STAY THE SAME, OR WOULD YOU SAY IT MIGHT CHANGE COLOR AND IT MIGHT STAY THE SAME?

121. ARE YOU SURE?

a) "Yes." [Continue.]

b) "No." WHY AREN'T YOU SURE?

122. WHY WOULD YOU SAY THAT? TRY IT.

II. CHEMICALS PART:
Discussion of Testing Instructions and Evaluation

Introduction.

Here S becomes familiar with the framework of the experiment. He is told that he will be asked different kinds of questions and is urged not to guess when he can't figure out an answer. It is hoped that an introduction such as this will keep a child from getting discouraged during the test and will assure him that "I don't know" can be just as 'correct' a response as a straight 'yes' or 'no'. With young children T sometimes adds, "Remember, 'maybe' or 'I don't know' is the right answer, too, sometimes." Careful observation along with the need to give reasons for answers are stressed in the introduction.

Introduction to Materials and Basic Understanding of Major Premise.

When children see the materials presented in this experiment, their first tendency seems to be to want to dig in and experiment, without taking time to consider T's questions. Therefore, initially T allows the child to discover some reactions, 'play' with the materials, and receive reinforcement from T as he describes what he sees. S is also given experience in a situation where he is missing some information, and is encouraged, for example, to say that he does not know what powders are in front of him. In an unhurried way, T can let S know that he is willing to pause and wait for responses. T also has the opportunity to observe S in order to determine length of attention span, type of vocabulary used, and the possibility of previous experiences similar to this one. These variables, in part, determine the direction and extent of T's departures from the script later on.

During this part of the experiment, T should make sure that S sees and comments on the reactions creating bubbles and milkiness.

Basic Understanding.

Procedure: See script, #8-20.

This part of the test should enable the subject to learn that vinegar always makes soda bubble. Young children, however, sometimes seem unable to make such a generalization. When this inability is present, the 'results' on the rest of the test become meaningless. The tester, therefore, must assume that inability to state and believe a major premise points to a like inability to do the type of conditional reasoning tested later on.

Before he is allowed to move ahead from this part of the test, S must: (1) predict correctly the results of adding vinegar to soda, (2) state that he is sure of his prediction, and (3) choose the appropriate signs for the bulletin board. If S is able to do (1) and (2) to the tester's satisfaction, he may receive help with (3), but T should try to clear up all misunderstandings about the use of the signs before he expects S to use them later as memory aids.

Conversion - Suppositional Form.

Procedure: See script, #21-26.

The purpose of all 'conditional' principles is to test S's ability to do thinking in which he uses an imagined minor premise. T may need to depart from the script to make #22 understandable to the young child. If, after repetition, S's attention seems to wander, however, it may be best to go on to the factual form of conversion. The words 'white stuff' were used instead of 'white powder' because many children tested interpreted 'white powder' to mean face powder or gun powder instead of 'any white substance'. The word 'substance' seemed too difficult for first graders.

Evaluation:

S's answer to #24 can be placed in one of four categories: Yes, for sure (it would be soda); No, for sure (it would not be soda); Maybe (it might be soda and it might not; I don't know what it is; or, I can't tell); or no answer. Both 'yes' and 'no' answers are considered incorrect and are coded W. A 'maybe' answer was designated by a check. 'No answer given' was coded 0.

Next, the kind of answer given to #26 was coded. If the subject is unable to answer #26 after further probes by T (see script), he is given an 0. An 0 could be received by S for responses such as "I really don't know why I chose that answer", or "I just know that I am right", as well as an extended pause.

If S says 'yes' to #24 and reverses the antecedent and consequent of the major premise when answering #26, he is assumed to be thinking in terms of logical equivalence and his justification is coded E. For example, his answer to #24 might be "It is soda, for sure". An E answer to #26 would be "If something is soda, it will bubble when vinegar is added to it. So, if something bubbles, it has to be soda." Most E justifications are shortened versions of this explanation. T says, "Why do you think this stuff would be soda?" S replies, "Because you said it would bubble". If the minor premise, 'this substance would bubble', is simply repeated by S, and if S seems to be sure of his answer to #24, S is assumed by T to have an equivalence relationship in mind.

If S seems to employ some form of mistaken reasoning that does not fall in the category of E, his justification in #26 is coded M. Examples of this might be "The stuff would be soda because it is white", or "The stuff would be soda because I think that is the only kind of white stuff you have with you". Before coding an M, however, T would be wise to check S's understanding of the premises.

The justifications for the answer 'maybe' to #24 can be quite varied and ticklish to evaluate. Of course, if S does not give a reason for his answer, he is coded 0. If, however, he says, "I couldn't tell what kind of white stuff was in the jar because I wouldn't have seen where you got it", a C would be coded as his justification. If S's reason was more general and less concrete such as, "You haven't told me or showed me enough for me to judge whether or not that stuff is soda", his justification would be coded I. An I would be considered by T to be a stronger justification than C. Often it is difficult to tell if a justification is to be coded C or I, but generally a C means that S has said that he wouldn't know about anything he hasn't actually seen, whereas an I means that S has said that he wouldn't know enough to figure out the answer to #24.

A stronger type of justification still occurs when S is mature enough to visualize alternatives to the white stuff being soda, saying, perhaps, "Maybe other things besides soda can bubble when vinegar is added to them". This kind of answer to #26 is coded A.

In summary, S's logical conclusion, his answer to #24, can be coded W, ✓, or 0. S's justification, his answer to #26, can be coded 0, E, M, C, I, or A. The answer sheets illustrate the grading very clearly. For mastery of the item S must give the correct answer and an I or A justification.

Conversion - Factual Form.

Procedure: See script, #27-32.

Here, S is actually given a substance to test. Before he begins adding vinegar to it, however, he is asked if he can tell what it is by looking at it. If he thinks he can, T must find out why and convince him that he has no real way of knowing what it is. If S remains unconvinced and still says "It has to be soda", or "It can't be soda", there is no point in continuing the experiment, as S will not notice or will discount the reaction he sees.

It is the opinion of this writer that the factual form of conversion provides S with a greater temptation to guess than any other principle in the test. S sees a substance bubbling in front of him, remembers that soda bubbled in just the same way, and immediately concludes that this has to be soda. Thus, T must be very careful not to skip #31 and to insist on a coherent answer for #32 if this is at all possible.

Evaluation:

As in the suppositional form of conversion, S's conclusion is coded W, ✓, or O. His justification (the answer he gives to #32) is coded O, E, M, C, I, or A. Mastery is assumed for the item if a correct answer and an I or A justification is given.

Contraposition - Suppositional Form.

Procedure: See script, #33-37.

T may have to emphasize the negatives in the script in order to make S fully aware of the imagined conditions in the experiment. Review of the major premise (#34) is also quite important in order to keep S from becoming confused.

Evaluation:

As in conversion, S's conclusion, his answer to #35, may be 'yes', 'no', 'maybe', or no answer. The correct line of reasoning would require S to conclude that if soda always bubbles when vinegar is added to it (S must be convinced that this is true, of course) and if a certain unknown substance does not, then the unknown substance cannot be soda. This response (no) is coded ✓. If S answers, "Yes, the substance would be soda", his understanding of the premises should be checked by T. If he persists, however, a 'yes' answer would be coded W. Since a 'maybe' answer may be more a result of lack of confidence than S's inability to reason effectively, it is coded separately as an M. No answer is coded 0.

S's justification, his answer to #37, generally is coded in accordance with the rules discussed under Conversion - Suppositional Form. Some specific examples may be helpful. An '0' means either that S has not answered #37 or that he has said something equivalent to "I just know". An E means that S has reversed the antecedent and consequent of the major premise somewhere in his explanation. For instance, he might say, "If something bubbles when vinegar is added to it, it is soda. If something does not bubble, it is not soda." (The first statement, which is incorrect, is derived by S from the information, 'If a substance is soda, it will bubble when vinegar is added to it'.) An M is coded if S's explanation shows some form of mistaken reasoning that is not E. ("If something doesn't bubble, it isn't soda because you might have used up all the soda.") An

A, I, or C justification of a 'maybe' response is usually not appropriate for contraposition, and may mean that S has misunderstood the premises. A C type of justification may also mean that S has no confidence in his ability to figure out an answer if he hasn't seen the powder T is using.

The strongest justification for the suppositional form of contraposition occurs when S is able to recall and state one or both premises he has used in coming to his conclusion. For example, he might say, "I know that the white stuff would not be soda if it didn't bubble because if something is soda it will bubble if vinegar is added to it". Here, he has repeated the major premise in his justification, and his answer is coded V_M. If he responds to #37 by saying, "It can't be soda because you said it wouldn't bubble", he is repeating the minor premise, and his answer is coded V_m. If he uses both premises in his justification, it is coded V_{Mm}, or simply V. Mastery or a score of (1) was assumed if the correct answer was accompanied by a V or V_M justification. Credit was also given if, along with a statement of a correct reason for his answers, e.g., V_M, S included another statement which showed he was making the equivalence error, and if he had also received a zero for inversion and conversion. The reasoning here was that S should not be docked twice for the same logical error.

Contraposition - Factual Form.

Procedure: See script, #38-42.

Evaluation: Use code letters discussed under Contraposition - Suppositional Form.

Inversion - Suppositional Form.

Procedure: See script, #43-47.

Evaluation:

Since this is an invalid move, the coding of S's conclusion and justification is similar to the coding discussed in reference to conversion. S's conclusion is coded W if his answer is, "It would bubble for sure", or "It would not bubble for sure". It is coded ✓ for an answer using "maybe", or "I can't tell for sure". An 0 is given if S makes no response.

S's justification, his answer to #47, would be coded 0 if he does not respond; E if he says, "If this is soda, it will bubble; if it is not soda, it won't bubble"; M for some other kind of mistaken reasoning. In this move, however, it was felt that a C and an I response were indistinguishable, and so the answer is coded I whenever S says that he needs to know or "see" what the powder is before he can tell what it will do. Again, A is the strongest form of justification here, and is given if S says that the substance might not bubble (because some substances that are not soda don't bubble) and it might bubble (because some substances which are not soda do bubble). Mastery is assumed, i.e., a score of (1) given, if a correct answer plus a C, I or A justification is given.

Inversion - Factual Form.

Procedure: See script, #48-49.

Evaluation: See discussion of the evaluation for Inversion - Suppositional Form.

Repetition of the Conversion, Contraposition and Inversion Principles, Using Sugar (Lactose) Instead of Soda.

Procedure: See script, #50-91.

The reaction of sugar and vinegar is not as dramatic as the reaction of vinegar and soda. Thus, T may find that more review is necessary in order to establish the major premise securely. For more mature subjects the central premise: "If this is sugar, it will not bubble and will turn the vinegar a whitish color when vinegar is added to it", may be changed to, "If this is sugar, it will not foam (or fizz) up and will turn vinegar a whitish color when vinegar is added to it". A problem with the words, 'will not bubble', occurs if S sees an air bubble or two.

Evaluation: See discussion of the corresponding principles using soda.

Transitivity - Suppositional Form.

Procedure: See script, #92-115.

This is a test of the transitivity principle, which may be expressed specifically as follows:

Premise: If this liquid is vinegar, it will make soda bubble.

Premise: If a liquid makes soda bubble, it will also make blue litmus paper change color.

Conclusion: If this liquid is vinegar, it will make blue litmus paper change color.

Since this move is tested at the end of a long session, T may need to give S a chance to relax between #91 and #92. Also, there may be some tendency for S not to believe that the premises are always true. Each premise should be established clearly using the same language every time, and S should be quizzed on the premises before he is asked to form a conclusion. (See #108 and #110.)

Evaluation:

A 'yes' answer to #113 (vinegar would make the paper change color) would be coded ✓; a 'no' answer would be coded W; a 'maybe' answer would be coded M; no response would be coded 0.

A strong justification in which the subject used the two main premises to establish his line of reasoning would be coded V. If S gives an inappropriate reason for an answer (vinegar looks like water so it won't make the litmus paper change color), he is given an M. No response is coded 0.

Transitivity - Factual Form.

Procedure: See script, #116-120. Note that the premise, "If something makes soda bubble, it will make the blue litmus paper change color", is not reviewed again. This is in order to avoid too many verbal clues for S.

Evaluation: See discussion of the evaluation for Transitivity - Suppositional Form.

III. HOUSE PART: Script

Testing Instructions (Time: 20-30 minutes).

Materials needed (see illustration for the physical layout of the test).

Wooden house with doorbell, light, and two switches shaped like handles.
Extra bulbs and batteries.
Magnetic board and the following pictures:
- large handle up (2)
- large handle down (2)
- light on
- bell ringing (2)
- bell not ringing (2)
- light off

Tapes and recorder.

Preparation.

1. A table is moved so that one end is against a wall and S and T can sit on opposite sides facing each other.

2. The magnetic board is placed so that it is supported by the wall and is within easy reach of S.

3. The pictures are placed face up by T but out of reach of S.

4. The house is also placed or held beyond S's reach with the front of the house toward S, and both handles down.

5. Be certain connections are sound and the house is in good working order.

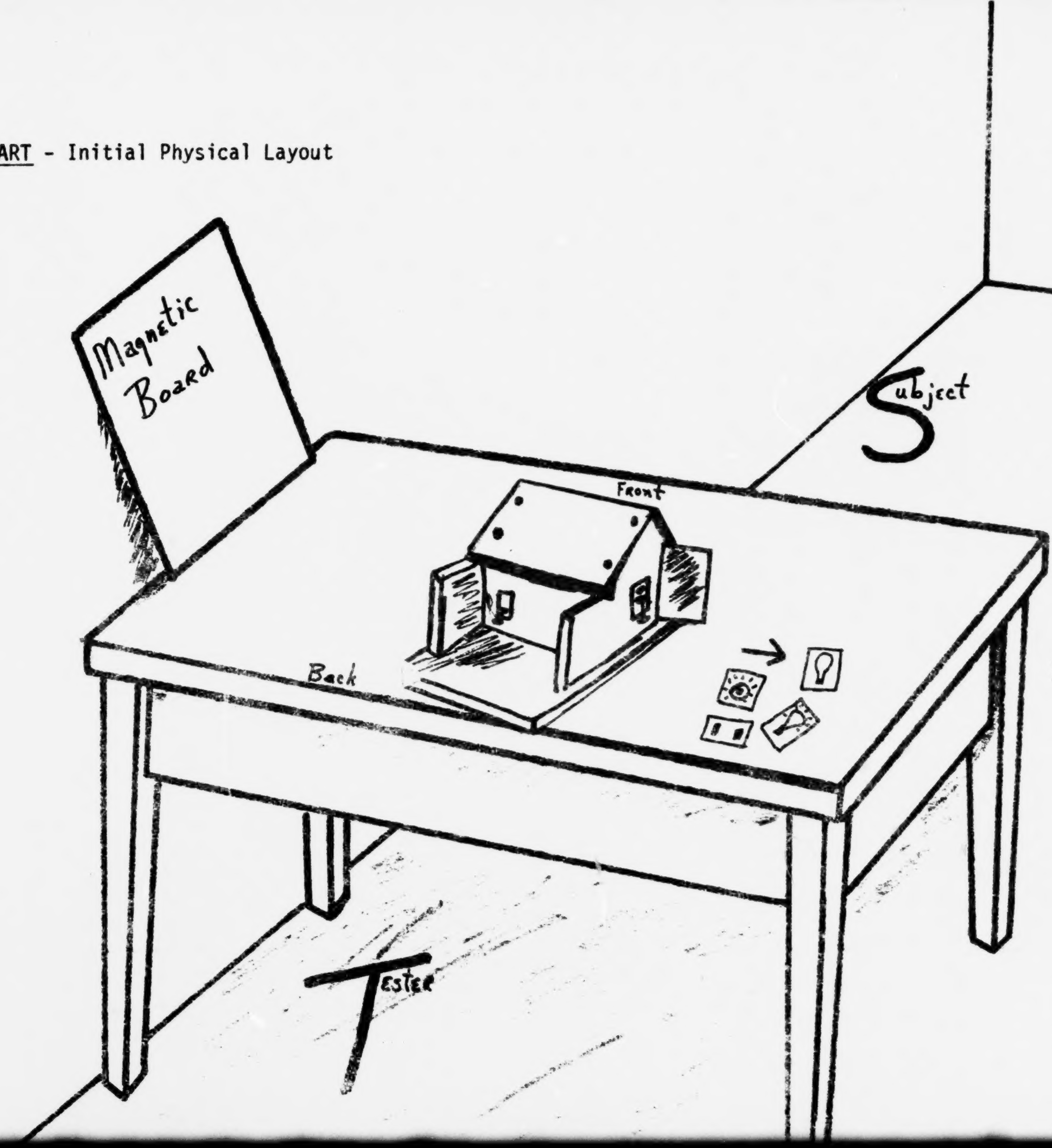
6. Do not let S handle the house freely until after the test period.

7. SCRIPT:
   All capitalized words - what Tester (T) says.
   Brackets - what Tester does.
   Quotations ("....") - possible responses of Subject (S).

General rules of procedure.

In all cases in which S seems to give an 'illogical' answer or justification, T should depart from script (casually) and review premises and question with S. T should also probe justifications further wherever this seems necessary.

HOUSE PART - Initial Physical Layout


Magnetic Board
Subject
Front
Back
Tester

Note: Pictures and house should be out of reach of the subject.

Introduction.

THIS IS A PUZZLE WHICH WILL TEST HOW WELL YOU CAN THINK. FIRST, YOU WILL FIND OUT SOME THINGS ABOUT THE WAY THIS HOUSE WORKS. THEN, YOU WILL SEE IF YOU CAN REMEMBER WHAT YOU LEARNED IN ORDER TO ANSWER SOME OTHER QUESTIONS. I'M GOING TO TELL YOU SOME THINGS. YOU WILL SEE SOME THINGS. BUT SOME THINGS YOU WON'T KNOW ABOUT THE HOUSE. FOR EXAMPLE, IF I ASKED YOU WHAT IS IN THE FRONT OF THIS HOUSE, YOU COULD TELL ME. WHAT WOULD YOU SAY? DO YOU KNOW WHAT IS INSIDE THE HOUSE? NO, YOU DON'T KNOW BECAUSE YOU HAVEN'T LOOKED AND I HAVEN'T TOLD YOU. IF YOU CAN'T FIGURE OUT A WAY TO ANSWER A QUESTION, OR IF I ASK ABOUT SOMETHING YOU HAVEN'T SEEN FOR SURE, DON'T TRY TO GUESS. JUST SAY, "I DON'T KNOW", OR "I CAN'T TELL". SOMETIMES "I DON'T KNOW", OR "MAYBE" IS THE RIGHT ANSWER; SOMETIMES "YES", OR "NO" IS THE RIGHT ANSWER. I WILL ALSO ASK YOU TO GIVE ME REASONS OR TELL ME HOW YOU FIGURED OUT THE ANSWERS YOU HAVE GIVEN. SO DON'T BE SURPRISED OR THINK YOUR ANSWER IS WRONG WHEN I SAY: "ARE YOU SURE OF THAT ANSWER?", OR "HOW DID YOU DECIDE THAT?" ARE YOU READY TO BEGIN? REMEMBER, THIS HOUSE IS DIFFERENT FROM OTHER HOUSES YOU MAY HAVE SEEN. DON'T THINK THAT THE BELL AND THE HANDLES ON THIS HOUSE HAVE TO WORK THE SAME AS OTHER BELLS AND HANDLES YOU HAVE SEEN.

Introduction to Major Premise - Basic Understanding.

1. [The front of the house is toward S.] THIS HOUSE HAS A DOORBELL.

SOMETIMES IT CAN WORK IF YOU PUSH THIS BUTTON. SOMETIMES IT CANNOT WORK. CAN IT WORK NOW? [S̲ tries the bell. Since both handles have been placed in a 'down' position by T̲, the bell will not ring.]

2. NOW I'LL SHOW YOU SOME OTHER THINGS ABOUT THIS HOUSE. THERE IS A LITTLE HANDLE IN BACK OF THE HOUSE. YOU CAN SEE THAT IT CAN BE MOVED UP OR DOWN [T̲ demonstrates], BUT I WILL NOT TELL YOU IF IT MAKES ANYTHING WORK UNTIL AFTER OUR EXPERIMENT.

3. [Without showing S̲, T̲ has moved the big handle on the side of the house to an 'up' position. Then the side of the house with the handle is turned toward S̲.] NOW WE'LL LOOK AT THE BIG HANDLE ON THE SIDE OF THE HOUSE. IT CAN ALSO BE EITHER UP OR DOWN. [T̲ demonstrates, moving handle down, then up again.] IF THE HANDLE IS UP, CAN THE BELL WORK? [S̲ tries the bell.] YES, YOU HAVE JUST FOUND OUT THAT IF THE BIG HANDLE IS UP, THE BELL CAN WORK: AND I WILL TELL YOU THAT IF THE BIG HANDLE IS UP, THE BELL WILL ALWAYS WORK, NO MATTER WHAT WE DO TO THE REST OF THE HOUSE (UNLESS THE HOUSE IS BROKEN, OF COURSE). TRY RINGING IT AGAIN! THE HANDLE IS UP, SO THE BELL WORKS.

4. YOU MIGHT HAVE FIGURED OUT SOME OTHER THINGS, BUT YOU SAW THAT IF THE HANDLE IS UP THEN THE BELL RINGS. [If S̲ volunteers at any time during the test that he thinks that if the big handle is up the bell rings and if it is down it doesn't ring, T̲ should say, "How did you decide those things? Do you see both of them for sure?" He should accept any answer given by S̲ noncommittally but should review the major premise, "If the big handle is up, the bell will work".]

5. [T shows S pictures of the big handle in an up and a down position.] WHICH PICTURE SHOWS THAT THE BIG HANDLE IS UP? [Place on board.]

6. IF THE BIG HANDLE IS UP LIKE THIS, WHAT DO WE KNOW ABOUT THE BELL? [Place picture of bell ringing on board.]

7. [Front of the house is toward S.] IN A MOMENT I WILL SHOW YOU THE BIG HANDLE. SEE IF YOU CAN TELL IF THE DOORBELL CAN WORK OR NOT. REMEMBER, IT'S ALL RIGHT TO SAY, "MAYBE IT CAN WORK, AND MAYBE IT CAN'T".

8. [T moves the big handle up and turns that side of the house toward S.] IS THE BIG HANDLE UP OR DOWN?

9. CAN THE BELL WORK, OR WOULD YOU SAY, "MAYBE IT CAN, AND MAYBE IT CAN'T"?

10. ARE YOU SURE? TRY IT. [Repeat 8, 9, and 10 as often as necessary to convince S that if the big handle is up, the bell will always work. For a first grader or fidgety child you may want to repeat several times.]

Conversion - Suppositional Form.

11. [Turn the front of the house toward S.] IF THE BIG HANDLE IS UP [show picture], WHAT DO YOU KNOW ABOUT THE BELL?

12. PRETEND THAT YOU PUSHED THE BUTTON ON THE BELL AND THE BELL RANG. WHAT ARE YOU PRETENDING?

13. IF YOU PUSHED THE BUTTON ON THE BELL AND THE BELL RANG, WOULD YOU SAY THAT THE BIG HANDLE IS UP OR ISN'T UP, OR WOULD YOU SAY THAT MAYBE IT

IS AND MAYBE IT ISN'T? [IF "I don't know", then....] DO YOU MEAN YOU ARE CONFUSED AND DON'T KNOW, OR DO YOU MEAN YOU CAN'T TELL, YOU DON'T HAVE ENOUGH INFORMATION? ARE YOU SURE OF THAT ANSWER?

a) "Yes." [Go to #14.]

b) "No." WHY AREN'T YOU SURE?

14. a) "Maybe." WHY WOULDN'T YOU KNOW ABOUT THE BIG HANDLE? [An attempt here to find out whether S̲ means he doesn't know because he can't 'see' the answer, or because he can't 'figure out' the answer.]

b) "Yes", "No". [Go to #15.]

15. HOW WOULD YOU KNOW THAT? [Here T̲ probes to see what S̲ is thinking. In particular, T̲ is trying to find out if S̲ is making an equivalence error or whether S̲ thinks he has seen something he actually hasn't, such as that if the bell rings the handle is up. In the latter case, T̲ makes clear what S̲ has actually seen, though noting that he may have figured out some other things.]

Conversion - Factual Form.

16. [Big handle is down, little handle is up, but do not show to S̲.] PUSH THE BUTTON ON THE BELL. CAN THE BELL WORK? "Yes."

17. IS THE BIG HANDLE UP, OR IS IT NOT UP, OR CAN'T YOU FIGURE OUT WHETHER IT'S UP OR NOT UP? "Maybe." ARE YOU SURE?

a) "Yes." [Go to #18.]

b) "No." WHY AREN'T YOU SURE?

18. a) "Maybe." WHY CAN'T YOU TELL?
    b) "Yes", "No". HOW DO YOU KNOW? "I haven't tried it." SEE IF YOU CAN FIGURE OUT ANY MORE! OR, DON'T YOU HAVE ANY MORE INFORMATION?

Inversion - Suppositional Form.

19. I ASKED YOU THIS BEFORE, BUT LET'S SEE IF YOU STILL REMEMBER. IF THE BIG HANDLE IS UP, CAN THE BELL WORK?

20. YES, IF THE BIG HANDLE IS UP, THE BELL CAN WORK.

21. NOW PRETEND THAT THE BIG HANDLE IS NOT UP LIKE THIS [picture]. WHAT ARE YOU PRETENDING? DO YOU KNOW IF THE BELL CAN WORK OR CAN'T WORK, OR WOULD YOU SAY MAYBE IT CAN AND MAYBE IT CAN'T? ARE YOU SURE OF THAT ANSWER?
    a) "Yes." [Go to #22.]
    b) "No." WHY AREN'T YOU SURE?

22. a) "Maybe." WHY CAN'T YOU TELL?
    b) "Yes", "No." HOW DO YOU KNOW?

23. HOW WOULD YOU KNOW THAT? (WHAT MAKES YOU THINK THAT?)

Inversion - Factual Form.

24. NOW LOOK AT THE BIG HANDLE.

25. DO YOU KNOW IF THE BELL CAN WORK OR CANNOT WORK, OR WOULD YOU SAY MAYBE IT CAN AND MAYBE IT CAN'T?

26. HOW WOULD YOU KNOW THAT?

Contraposition - Suppositional Form.

27. [Show the front of the house to S.] IF THE BIG HANDLE IS UP, DO YOU KNOW ANYTHING ABOUT THE BELL? [Picture.]

28. YES, IF THE BIG HANDLE IS UP, THE BELL CAN WORK.

29. PRETEND THAT YOU TRIED TO RING THE BELL AND THE BELL DIDN'T RING. WHAT ARE YOU PRETENDING?

30. WOULD YOU KNOW ANYTHING ABOUT THE BIG HANDLE? WOULD YOU KNOW IF IT WAS UP OR WAS NOT UP, OR WOULD YOU SAY MAYBE IT WAS UP AND MAYBE IT WASN'T? "Handle is not up." ARE YOU SURE?

31. a) "Yes" or "No". HOW COULD YOU TELL?
    b) "Maybe." WHY COULDN'T YOU TELL ANYTHING?

32. WHAT MADE YOU DECIDE THAT? "The bell didn't work."

Contraposition - Factual Form.

33. [Both handles are down.] NOW TRY TO RING THE BELL. CAN IT WORK? "No, the bell can't work."

34. IS THE HANDLE UP OR NOT UP, OR COULD IT BE EITHER UP OR NOT UP?
    a) "Down." ARE YOU SURE?
    b) "Up", or "Either". [Go to #35.]

35. HOW DO YOU KNOW?

36. WHAT MADE YOU DECIDE THAT? WHAT DID YOU SEE OR DO? ALL RIGHT, THE BELL DIDN'T WORK. WHAT MADE YOU DECIDE THE HANDLE MUST BE DOWN IF THE BELL DOESN'T WORK?

Understanding of Premises for Transitivity.

37. [Remove pictures from the board. Window shade side of the house is toward the subject.] SLIDE OPEN THE WINDOW SHADE, AND TELL ME WHEN YOU SEE A LIGHT INSIDE OF THE HOUSE.

38. [Large handle side of the house toward S.] LOOK AT THE BIG HANDLE.

39. WHERE IS THE BIG HANDLE? "Up."

40. IF YOU SEE THAT THE LIGHT IS ON, WHAT WOULD YOU KNOW ABOUT THE BIG HANDLE? "The handle is up."

41. YES, THE ONLY TIME THAT THE LIGHT IS ON IS WHEN THE LARGE HANDLE IS UP. SO IF THE LIGHT IS ON YOU KNOW THAT THE BIG HANDLE IS UP. [Use pictures. Light on, handle up. Pictures put on board in this order.] WHAT DO THESE PICTURES TELL YOU?

42. NOW CLOSE THE SHADE.

43. DO NOT TOUCH THE HOUSE, BUT LOOK AT THE BIG HANDLE AND PICK UP THE PICTURE THAT SHOWS HOW THE BIG HANDLE LOOKS. IS IT UP OR DOWN? "Up." [T puts picture on board.]

44. WHEN THE BIG HANDLE IS UP, DO YOU KNOW ANYTHING ALREADY ABOUT WHETHER

THE BELL CAN WORK OR NOT? WHAT? "Handle up, bell works." [Place pictures illustrating this on the board beneath the pictorial statement already there.]

45. YES, IF THE BIG HANDLE IS UP, THE BELL CAN WORK. [Use pictures.]

Conclusion for Transitivity (I) - Suppositional Form.

46. NOW PRETEND THAT YOU LOOKED THROUGH THE WINDOW AND SAW THE LIGHT BUT DIDN'T SEE ANYTHING ELSE. WHAT ARE WE PRETENDING?

47. WOULD YOU KNOW THAT THE BELL CAN WORK OR THE BELL CAN*NOT* WORK, OR WOULD YOU SAY MAYBE THE BELL CAN WORK AND MAYBE IT CAN'T? YOU CAN'T SAY FOR SURE?

48. a) "Yes, the bell can work." [If #47 was affirmative,...] HOW DO YOU KNOW?

    b) "No, the bell can't work."

49. TELL ME, STEP BY STEP. HOW DID YOU KNOW THAT? WHAT MADE YOU DECIDE THAT? [If *S* says as justification that the handle works the bell and light, say...] CAN YOU TELL ME WHAT YOU ARE THINKING, STEP BY STEP? NOW WE *SAW* THAT THE LIGHT WAS ON, AND WE WANT TO KNOW WHETHER THE BELL CAN WORK OR NOT.

Conclusion for Transitivity (I) - Factual Form.

50. [The big handle is up.] OPEN THE SHADE.

51. IS THE LIGHT ON?

52. CAN THE BELL WORK? OR CAN'T IT? OR WOULD YOU SAY MAYBE IT CAN AND MAYBE IT CAN'T?

53. [If S answers, "The bell can ring",..] TELL ME STEP BY STEP HOW YOU KNEW THE BELL WOULD RING WHEN YOU SAW THE LIGHT ON. HOW DO YOU KNOW? TRY IT.

Transitivity (II) - Suppositional Form.

[All handles down and remove all pictures from the board.]

54. NOW LET'S LOOK AT THE BIG HANDLE AND SEE HOW IT LOOKS WHEN THE BELL CAN'T WORK. IS IT UP OR DOWN? "Down."

55. YES, IF THE BELL DOESN'T WORK, YOU KNOW THAT THE BIG HANDLE IS DOWN. [Pictures placed on the board.]

56. [Open the shade.] IF THE BIG HANDLE IS DOWN, WHAT HAPPENS TO THE LIGHT?

57. YES, IF THE BIG HANDLE IS DOWN, THE LIGHT IS OFF. [Pictures.]

58. NOW SUPPOSE THAT YOU TRIED TO RING THE BELL IN FRONT OF THE HOUSE AND IT DIDN'T WORK.

59. WOULD YOU KNOW THAT THE LIGHT IS ON OR IS NOT ON, OR WOULD YOU SAY MAYBE IT'S ON AND MAYBE IT'S NOT? "Is not on."

60. HOW DO YOU KNOW? ARE YOU SURE?

61. WHAT MADE YOU DECIDE THAT?

Transitivity (II) - Factual Form.

62. NOW TRY TO RING THE BELL. CAN IT WORK? "No."

63. DO YOU KNOW IF THE LIGHT IS ON OR OFF, OR CAN'T YOU TELL? "Light off."

64. HOW DO YOU KNOW? (WHAT DID YOU LEARN ABOUT THE HOUSE THAT MADE YOU DECIDE THAT?)

III. HOUSE PART:
Discussion of Testing Instructions and Evaluation

Introduction.

This test is placed for the child in the context of a scientific experiment or puzzle instead of a 'game'. The purpose of this type of wording is to prevent carelessness among older children, who may think that 'playing with a house' is beneath them. Through the introduction S learns that some information will be denied him, at least temporarily, and that it is sometimes 'right' to say, "I don't know".

The principles and forms tested with the house are exactly the same as those in the Chemicals Part. The problems in testing and evaluation are somewhat different, however. It is these problems to which we will devote the major portion of this discussion.

Introduction to Major Premise - Basic Understanding.

As in the Chemistry Part, Basic Understanding serves as sort of a pretest to determine S's readiness to do more difficult types of deductive thinking. In this first part of the test S must be convinced that, always, if the big handle is up, the bell can work. S's answer to #9 must be correct; he must answer affirmatively to #10; and he must choose the correct pictures for the bulletin board in #5 and #6, before he is allowed to continue with the test.

Conversion - Suppositional Form.

Procedure: See script, #11-15.

Numbers 11 and 12 are attempts to establish S's awareness of the major and minor premises. T should not hesitate to depart from the script in order to make these clear to the young subject.

Although it appears that #14 and #15 are asking the same kind of question, S's responses to each are often quite different and tend to clarify his reasoning and the justification for his answer to #13. For example, he might say that the big handle would be up if he heard the bell ring (an incorrect conclusion since there might be something besides the big handle which causes the bell to ring). His answer to #14 might be, "If the handle is up the bell rings. If the handle is down the bell doesn't ring. [Incorrect.] So, if the bell rings the handle is up for sure." His answer to #15 might be, "I saw how the bell worked at the beginning", to which the tester replies, "What exactly did you see?" S may repeat his answer to #14, thus showing T that he thinks he has seen something which in fact he hasn't, or S may decide upon further thought that he hasn't seen both those things and may wish to change his answer.

Evaluation:

Since this is a fallacy principle, the correct answer to #13 would be, "Maybe the handle is up and maybe it is down". This response, or its equivalent, is coded ✓. A 'yes' or 'no' answer is coded W. No response is coded 0.

S's justification is interpreted by combining his answers to #14 and #15. If he denies the antecedent of the major premise and says, "If the handle is not up, the bell won't ring", or affirms the consequent of the major premise as his sole explanation and says, "If the bell rings, we know that the handle must be up", he is assumed to be seeing the relationship of antecedent and consequent in terms of equivalence and is coded

E. If he employs some other form of mistaken reasoning, his justification is coded M. No response is coded 0.

If S says that he wouldn't know whether the handle is up or down and gives "I can't see it" as his justification, he is coded C. If S says, "I need more information to tell for sure if the handle is up or down", he is given an I. An A means that S realizes and states that there are other possible causes of the ringing bell. ("The handle could be up or there might be something else making the bell ring.")

An E, M, C or 0 justification is interpreted to mean that mastery of conversion has not occurred. An I or A tends to show T that mastery has occurred.

Conversion - Factual Form.

Procedure: See script, 316-18.

In addition to using the words in #16-18, T may review the major premise with S. Usually this is not necessary, however, and tends to make the test 'drag'. T's responses to S's statements should, as usual, be non-committal. T also should not hesitate to depart from the script in order to probe for further justification if S's answer to #18 is unclear.

Evaluation: See the discussion for Conversion - Suppositional Form.

Inversion - Suppositional Form.

Procedure: See script, #19-23.

As in the suppositional form of conversion, the last two questions in this section are similar but may evoke responses which are quite different. For example, #22 might be answered, "I don't know if the bell can work or not because something besides this handle might be making the bell work. Or, the bell might not work because the handle is down". S's response to "What makes you think that?", #23, might be, "You said that there are some things I will not know about the house". These two responses together point toward a stronger justification than either would if stated separately.

Evaluation:

Since the correct response to #21 is "Maybe", S's answers may be evaluated using the code letters discussed in Conversion - Suppositional Form.

Answers to #22 and #23 would also be coded in the same way as in the suppositional form of conversion. Some examples of possible answers and the code letter they would receive are listed below:

E: The bell won't ring because the handle is down. (If the handle is up, the bell will ring; if it is down, it won't.)

C: I don't know if the bell will ring or not because I haven't tried the bell.

M: The bell won't ring because it just rang awhile ago, and it's tired now.

O: The bell will ring because I just know it will. Or, the bell won't ring because I just know it won't.

I: The bell might ring and it might not. I don't know for sure because I have never tried to ring the bell when I have seen that the handle is down.

A: I know that the bell will ring if the handle is up, so I think it might not ring if the handle is down. I don't know that for sure, though, because some other thing might be able to make the bell work.

For inversion an I or A justification results in a score of one (mastery) if the correct answer has been given.

Inversion - Factual Form.

Procedure: See script, #24-26.

Evaluation: See discussion for Inversion - Suppositional Form.

Contraposition - Suppositional Form.

Procedure: See script, #27-32.

With this principle it is particularly important for T to make sure that both premises are fully understood by S before he asks for an answer to #30. Review of the premises after an incoherent answer to #30 tends to make S feel as if he has made a mistake.

Evaluation:

The 'best' answers to #31 and #32 would include a statement to the effect that if the handle is up, the bell will (always) ring, so if the bell doesn't ring, it can't be up. This would be coded V, since both major and minor premises are contained in the explanation. If S says only, "If the handle is up, the bell can work", his justification is coded V_M. If S says only, "You said that the bell wouldn't work", his answer is coded V_m.

Other possible answers to #31 and #32 might include a C response ("I don't know if the handle is up or not because I can't see it"), an M response, or an E response ("If the handle is down, the bell won't ring, so the handle has to be down if we can't hear the bell"). An O is given if there is no response.

In judging mastery, T considers a correct conclusion (the handle is down) and a V or V_M justification as showing S's understanding of contraposition. A C, M, V_m, O, or E response would tend to show that an invalid kind of deduction was used by S.

Credit was also given if, along with a statement of a correct reason for his answer, e.g., V_{i1}, S included another statement which showed he was making the equivalence error, and if he had already received a zero for conversion and inversion. The reasoning here was that S should not be docked twice for the same logical error.

Contraposition - Factual Form.

Procedure: See script, #33-36.

Evaluation: See discussion of evaluation for Contraposition - Suppositional Form.

Transitivity - Suppositional Form.

Premise: If the light is on, the big handle is up.

Premise: If the big handle is up, the bell can work.

Conclusion: If the light is on, the bell can work.

Procedure:

Care should be taken to insure S's complete understanding of both premises. This understanding can be checked by T by letting S select the pictures to be used in #41 and #43. Many repetitions may be necessary in order to establish the premises firmly.

Evaluation:

The answer, "The bell can work", is marked by a check. If S says, "The bell can't work", this receives a W. A "Maybe" answer is coded M.

Justifications usually fall into a V category in which S repeats one or more of the premises as the reason for his answer to #48 and #49, an M category in which S's justification shows mistaken reasoning, or an O category in which no justification is given.

Transitivity - Factual Form.

Procedure: See script, #50-53.

The premises are not reviewed again, since this appears unnecessary and seems to give S too many clues to use in forming his conclusion.

Evaluation: See discussion for Transitivity - Suppositional Form.

Transitivity is tested again using the following premises:

Premise: If the bell will not work, the handle is down.

Premise: If the handle is down, the light is off.

Conclusion: If the bell will not work, the light is off.

Since in this second testing of transitivity the procedure and method of evaluation remain the same as those discussed above, T may review the former discussion if necessary.

GRADE SHEET FOR THE SMITH-STURGEON CONDITIONAL REASONING TEST

Name of Subject ____________________

Date ____________________

School ____________________

Chemicals Part ____________________

Name of Tester ____________________

CHEMICALS PART GRADE SHEET

Principle I, Modus Ponens.

Items Evaluated Or Graded	Paragraph Number
1. Understanding of M. _____ a) Number of times #12 was repeated. _____	#12
2. Understanding of M. _____	#13
3. S's ability to put the pictures on the board correctly. _____	#16-20
4. Subjective evaluation. _____ a) Degree of understanding. _____	#16-20

NOTE: #13 must be done correctly to proceed with the test.

FINAL GRADE ☐

Principle III (Conversion), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#23
2. Understanding m. _____ "Pretend...dry, white stuff in jar; we add vinegar and it bubbles." a) How often was #22 repeated? _____	#22
3. Conclusion (final answer of subject). "...would you say the white stuff is soda, is not soda, etc.?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#24
4. Justification. _____(o) No justification. ...."I really don't know why I chose that." ...."I just know that I am right." ....Other. _____(e) Equivalence. ...."If something is soda, it will bubble when vinegar is added to it; if something bubbles it has to be soda." ...."Because it would bubble," in answer to the question 'why do you think this is soda?" _____(m) Mistaken reasoning. ...."Soda, because it is white." _____(c) Concrete reason. ...."Because I couldn't see it." ...."I haven't tried." _____(i) Indeterminate. ...."You haven't told me enough to judge whether or not the stuff is soda." (Couldn't figure it out.) _____(a) Strong. Visualizes alternatives. ...."Maybe other things can bubble when vinegar is added to them."	#26
5. Subjective evaluation. _____	

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle III (Conversion), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#27
2. Understanding m. _____ a) How often was #28 repeated? _____	#28
3. Conclusion (final answer of subject).	#30
4. Justification.	#32
5. Subjective evaluation. _____	

3. Conclusion (final answer of subject).
"...would you say the white stuff is soda, is not soda, etc.?"
_____(w) Yes.
_____(w) No.
_____(√) Maybe.
_____(o) No answer.

4. Justification.
_____(o) No justification.
...."I really don't know why I chose that."
...."I just know that I am right."
....Other.
_____(e) Equivalence.
...."If something is soda, it will bubble when vinegar is added to it; if something bubbles, it has to be soda."
...."Because it would bubble," in answer to the question 'why do you think this is soda?'
_____(m) Mistaken reasoning.
...."Soda, because it is white."
_____(c) Concrete reason.
...."Because I couldn't see it."
...."I haven't tried it."
_____(i) Indeterminate.
...."You haven't told me enough to judge whether or not the stuff is soda." (Couldn't figure it out.)
_____(a) Strong. Visualizes alternatives.
...."Maybe other things can bubble when vinegar is added to them."

5. Subjective evaluation. _____

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle IV (Contraposition), Conditional.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____ #34

2. Understanding m. _____ #33
"...pretend white stuff in jar which doesn't bubble when vinegar is added."
a) How often repeated? _____

3. Conclusion (final answer of subject). #35
"...if this white stuff did not bubble, would you say it is soda, is not, etc.?"
_____(w) Yes.
_____(✓) No.
_____(m) Maybe.
_____(o) No answer.

4. Justification. #37
_____(o) No justification.
...."I don't know."
_____(e) Equivalence.
...."If something bubbles when vinegar is added to it, it is soda (wrong); if something does not bubble, it is not soda."
_____(m) Mistaken reasoning.
...."You may have used up all the soda."
_____(c) Concrete.
...."Can't see it." (Need to see it to figure it out.)
...."Haven't tried it."
_____ v Strongest. (Uses both premises.)
a) If something is soda, it will bubble if vinegar is added.
b) If that white stuff didn't bubble, it would not be soda.
_____v_M Repeats a) above, the major premise as justification.
_____v_m Repeats b) above, "It can't be soda because you said it wouldn't bubble."

5. Subjective evaluation. _____

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle IV (Contraposition), Particular.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____ #38

2. Understanding m. _____ #39
   a) How often repeated? _____

3. Conclusion (final answer of subject). #40
   "...if this white stuff did not bubble, would you say it is soda, is not, etc.?"
   _____(w) Yes.
   _____(✓) No.
   _____(m) Maybe.
   _____(o) No answer.

4. Justification. #42
   _____(o) No justification.
   ...."I don't know."
   _____(e) Equivalence.
   ...."If something bubbles when vinegar is added to it, it is soda (wrong); if something does not bubble, it is not soda."
   _____(m) Mistaken reasoning.
   ...."You may have used up all the soda."
   _____(o) Concrete.
   ...."Can't see it." (Need to see it to figure it out.)
   _____ v Strongest. (Uses both premises.)
   a) If something is soda, it will bubble if vinegar is added.
   b) If that white stuff didn't bubble, it would not be soda.
   _____v_M Repeats a) above, the major premise as justification.
   _____v_m Repeats b) above, "It can't be soda because you said it wouldn't bubble."

5. Subjective evaluation. _____

FINAL GRADE ☐

Principle II (Inversion), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#44
2. Understanding m. _____ "...pretend white stuff that isn't soda." a) How often was #43 repeated? _____	#43
3. Conclusion (final answer of subject). "If this white stuff wasn't soda, would you say that it would bubble if we added vinegar, it wouldn't bubble, or it might...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	
4. Justification. _____(o) No justification. ...."I don't know." _____(e) Equivalence. ...."If this is soda, it will bubble; if it is not soda, it won't bubble." _____(m) Mistaken reasoning. _____(i) (Same as c) says he "needs to know or see what the powder is before he knows what it will do". _____(a) Strongest. a) Stuff might not bubble, because some substances that are not soda don't bubble. b) Stuff might bubble because some substances which are not soda do bubble.	#47
5. Subjective evaluation. _____	

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle II (Inversion), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#48
2. Understanding m. _____ a) How often was #43 repeated? _____	#48
3. Conclusion (final answer of subject). "If this white stuff wasn't soda, would you say that it would bubble if we added vinegar, it wouldn't, etc., or it might...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#49
4. Justification. _____(o) No justification. ...."I don't know." _____(e) Equivalence. ...."If this is soda, it will bubble; if it is not soda, it won't bubble." _____(m) Mistaken reasoning. _____(i) (Same as c) says he "needs to know or see what the powder is before he knows what it will do." _____(a) Strongest. a) Stuff might not bubble, because some substances that are not soda don't bubble. b) Stuff might bubble because some substances which are not soda do bubble.	#51
5. Subjective evaluation. _____	

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle I, Modus Ponens.

Items Evaluated Or Graded	Paragraph Number
1. Understanding of M. _____ "...vinegar added to sugar turns white and does not bubble." a) Number of times #12 was repeated. _____	#55
2. Understanding of m. _____	#57
3. S's ability to put the pictures on the board correctly. _____	#59-63
4. Subjective evaluation. _____ a) Degree of understanding. _____	

FINAL GRADE

Principle III (Conversion), Conditional.

Items Evaluated or Graded — Paragraph Number

---

1. Understanding M. _____ #65

2. Understanding m. _____ #64
"...pretend dry, white stuff in jar, add vinegar; then it turns white and doesn't bubble."
a) How often was #62 repeated? _____

3. Conclusion (final answer of subject). #66
"...would you say the white stuff is sugar, is not sugar?"
_____(w) Yes.
_____(w) No.
_____(✓) Maybe.
_____(o) No answer.

4. Justification. #68
_____(o) No justification.
...."I really don't know why I chose that."
...."I just know that I am right."
....Other.
_____(e) Equivalence.
...."If something is sugar, it will not bubble and will turn white when vinegar is added to it; if something does not bubble, it has to be sugar."
...."Because it would not bubble," in answer to the question 'why do you think this is sugar?'
_____(m) Mistaken reasoning.
...."Sugar, because it is white."
_____(c) Concrete reason.
...."Because I couldn't see it."
...."I haven't tried it."
_____(i) Indeterminate.
...."You haven't told me enough to judge whether or not the stuff is sugar." (Couldn't figure it out.)
_____(a) Strong. Visualizes alternatives.
...."Maybe other things do not bubble when vinegar is added to them."

5. Subjective evaluation. _____

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle III (Conversion), Particular.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____

2. Understanding m. _____ #70
   a) How often was #70 repeated? _____

3. Conclusion (final answer of the subject). #72
"...would you say the white stuff is sugar, is not sugar, etc.?"
_____(w) Yes.
_____(w) No.
_____(✓) Maybe.
_____(o) No answer.

4. Justification. #74
_____(o) No justification.
...."I really don't know why I chose that."
...."I just know that I am right."
....Other.
_____(a) Equivalence.
...."If something is sugar, it will not bubble when vinegar is added to it; if something does not bubble, it has to be sugar."
_____(m) Mistaken reasoning.
...."Sugar, because it is white."
_____(c) Concrete reason.
...."Because I couldn't see it."
...."I haven't tried it."
_____(i) Indeterminate.
...."You haven't told me enough to judge whether or not the stuff is sugar." (Couldn't figure it out.)
_____(a) Strong. Visualizes alternatives.
...."Maybe other things do not bubble and do turn white when vinegar is added to them."

5. Subjective evaluation. _____

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle IV (Contraposition), Conditional.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____

2. Understanding m. _____ #75
"...pretend white stuff in jar which bubbles when vinegar added."
a) How often repeated? _____

3. Conclusion (final answer of subject). #77
"...if this white stuff does bubble, would you say it is soda, is not, etc.?"
_____(w) Yes.
_____(✓) No.
_____(m) Maybe.
_____(o) No answer.

4. Justification. #79
_____(o) No justification.
...."I don't know."
_____(e) Equivalence.
...."If something does not bubble and does turn white when vinegar is added to it, it is sugar (wrong); if something does bubble, it is not sugar."
_____(m) Mistaken reasoning.
...."You may have used up all the sugar."
_____(c) Concrete.
...."Can't see it." (Need to see it to figure it out.)
_____ v Strongest. (Uses both premises.)
a) If something is sugar, it will not bubble and will turn white if vinegar is added.
b) If that white stuff did bubble, it would not be sugar.
_____v_M Repeats a) above, the major premise, as justification.
_____v_m Repeats b) above, "It can't be sugar because you said it would bubble."

5. Subjective evaluation. _____

FINAL GRADE ☐

Principle IV (Contraposition), Particular.

Items Evaluated Or Graded	Paragraph Number

1. Understanding M. _____

2. Understanding m. _____ #81
   a) How often repeated? _____

3. Conclusion (final answer of subject). #82
   "...if this white stuff did bubble, would you say it is sugar, is not, etc.?"
   _____(w) Yes.
   _____(✓) No.
   _____(m) Maybe.
   _____(o) No answer.

4. Justification.
   _____(o) No justification.
   ...."I don't know."
   _____(e) Equivalence.
   ...."If something does not bubble and does turn white when vinegar is added to it, it is sugar (wrong),...."
   _____(m) Mistaken reasoning.
   ...."You may have used up all the sugar."
   _____ v Strongest. (Uses both premises.)
   a) If something is sugar, it will not bubble and will turn white if vinegar is added.
   b) If that white stuff did bubble, it would not be sugar.
   _____v_M Repeats a) above, the major premise, as justification.
   _____v_m Repeats b) above, "It can't be sugar because you said it would bubble."

5. Subjective evaluation. _____

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle II (Inversion), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#86
2. Understanding m. _____ "...pretend this stuff is not sugar." a) How often was #85 repeated? _____	#85
3. Conclusion (final answer of subject). "If this white stuff wasn't sugar, would you say that it would bubble if we added vinegar, it wouldn't, etc., or it might...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#87
4. Justification. _____(o) No response. _____(e) Equivalence. ...."If this is sugar, it will not bubble; if it is not sugar, it will bubble." _____(m) Mistaken reasoning. _____(i) (Same as c) says he "needs to know or see what the powder is before he knows what it will do". "Has to try it." _____(a) Strongest. a) Stuff might not bubble, because some substances that are not sugar don't bubble. b) Stuff might bubble because some substances which are not sugar do bubble.	#89
5. Subjective evaluation. _____	

FINAL GRADE ☐

Principle II (Inversion), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	
2. Understanding m. _____ a) How often was #90 repeated? _____	#90
3. Conclusion (final answer of subject). "If this white stuff wasn't soda, would you say that it would bubble if we added vinegar, it wouldn't, etc., or it might...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#91
4. Justification. _____(o) No response. _____(e) Equivalence. ...."If this is sugar, it will not bubble; if it is not sugar, it will bubble." _____(m) Mistaken reasoning. _____(i) (Same as c) says he "needs to know or see what the powder is before he knows what it will do". _____(a) Strongest. a) Stuff might not bubble, because some substances that are not sugar don't bubble. b) Stuff might bubble because some substances which are not sugar do bubble.	#93
5. Subjective evaluation. _____	

FINAL GRADE ☐

Principle V (Transitivity), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#110
2. Understanding m. _____ "...pretend you tested vinegar with blue litmus paper."	#112
3. Conclusion (final answer of subject). "...would you say that vinegar would make paper change color...?" _____(✓) Yes. _____(w) No. _____(m) Maybe. _____(o) No answer.	#115
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. ...."Vinegar looks like water so it won't make litmus change color." _____(v) Strong. (Uses two premises.) ...."If the liquid is vinegar, it will make soda bubble." ...."If a liquid makes soda bubble, it will also make blue litmus paper change color." ...."If this liquid is vinegar, it will make blue litmus paper change color."	#117
5. Subjective evaluation. _____	

FINAL GRADE ☐

CHEMICALS PART GRADE SHEET

Principle V (Transitivity), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	
2. Understanding m. _____	(not restated)
3. Conclusion (final answer of subject). "...would you say that vinegar would make paper change color...?" _____(✓) Yes. _____(w) No. _____(m) Maybe. _____(o) No answer.	#120
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. ...."Vinegar looks like water so it won't make litmus change color." _____(v) Strong. (Uses two premises.) ...."If the liquid is vinegar, it will make soda bubble." ...."If a liquid makes soda bubble, it will also make blue litmus paper change color." ...."If this liquid is vinegar, it will make blue litmus paper change color."	#122
5. Subjective evaluation. _____	

FINAL GRADE ☐

GRADE SHEET FOR THE SMITH-STURGEON
CONDITIONAL-REASONING TEST

Name of Subject ______________________

Date ______________________

School ______________________

House Part ______________________

Name of Tester ______________________

HOUSE PART GRADE SHEET

Principle I, Modus Ponens.

Items Evaluated Or Graded	Paragraph Number
1. Understanding of M. _____ a) Number of times repeated. _____	#9
2. S's ability to put the pictures on the board correctly. _____	#5-6
3. Subjective evaluation. _____ a) Degree of understanding. _____	

NOTE: In order to proceed with the test #9 must be answered correctly, #10 must be answered with a yes, and #5 and #6 must be done correctly.

FINAL GRADE

HOUSE PART GRADE SHEET

Principle III (Conversion), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#11
2. Understanding m. "...push the button and the bell rings." a) How often was m repeated? _____	#12
3. Conclusion (final answer of subject). "...is the big handle up...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#13
4. Justification. _____(o) No justification. _____(e) Equivalence. a) "If the handle is not up, the bell won't ring." b) "If the bell rings, we know that the handle is up." c) "If the handle is up, the bell rings. If the handle is down, the bell doesn't ring. So if the bell rings, the handle is up." _____(m) Mistaken reasoning. _____(c) Concrete reason. ...."I can't see it." _____(i) Indeterminate. ...."I need more information to tell for sure if the handle is up or down." _____(a) Strong. ...."The handle could be up or there might be something else making the bell ring."	#14-15
5. Subjective evaluation. _____	

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle III (Conversion), Particular.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____

2. Understanding m. _____ #16
"...push the button and the bell rings."
a) How often was m repeated? _____

3. Conclusion (final answer of the subject). #17
"Is the big handle up...?"
_____(w) Yes.
_____(w) No.
_____(✓) Maybe.
_____(o) No answer.

4. Justification. #18
_____(o) No justification.
_____(e) Equivalence.
    a) "If the handle is not up, the bell won't ring."
    b) "If the bell rings, we know that the handle is up."
    c) "If the handle is up, the bell rings. If the handle is down, the bell doesn't ring. So if the bell rings, the handle is up."
_____(m) Mistaken reasoning.
_____(c) Concrete reason.
    ...."I can't see it."
_____(i) Indeterminate.
    ...."I need more information to tell for sure if the handle is up or down."
_____(a) Strong.
    ...."The handle could be up or there might be something else making the bell ring."

5. Subjective evaluation. _____

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle II (Inversion), Conditional.

Items Evaluated Or Graded — Paragraph Number

---

1. Understanding M. _____ #19

2. Understanding m. _____ #21
"The big handle is down."
a) How often was m repeated? _____

3. Conclusion (final answer of subject). #21 (latter part)
"...would you say the bell will ring...?"
_____(w) Yes.
_____(w) No.
_____(✓) Maybe.
_____(o) No answer.

4. Justification. #22-23
_____(o) No justification.
...."The bell will ring because I know it will."
...."The bell won't ring because I just know it won't."
_____(e) Equivalence.
...."The bell won't ring because the handle is down." (If the handle is up, the bell will ring; if it is down, it won't.)
_____(m) Mistaken reasoning.
...."The bell won't ring because it's tired."
_____(c) Concrete.
...."Don't know if it will ring as I haven't tried it."
_____(i) Indeterminate.
...."Bell might ring and might not. I don't know know for sure because I have never tried to ring the bell when the handle is down."
_____(a) Strong.
...."Don't know for sure as some other thing might make the bell work."

5. Subjective evaluation. _____

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle II (Inversion), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	
2. Understanding m. _____ "The big handle is down." a) How often was m repeated? _____	#16
3, Conclusion (final answer of subject). "...would you say the bell will ring...?" _____(w) Yes. _____(w) No. _____(✓) Maybe. _____(o) No answer.	#17
4. Justification. _____(o) No justification. ...."The bell will ring because I know it will." ...."The bell won't ring because I just know it won't." _____(e) Equivalence. ...."The bell won't ring because the handle is down." (If the handle is up, the bell will ring; if it is down, it won't.) _____(m) Mistaken reasoning. ...."The bell won't ring because it's tired." _____(c) Concrete. ...."Don't know if it will ring as I haven't tried it." _____(i) Indeterminate. ...."Bell might ring and might not. I don't know for sure because I have never tried to ring the bell when the handle is down." _____(a) Strong. ...."Don't know for sure as some other thing might make the bell work."	#18
5. Subjective evaluation. _____	

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle IV (Contraposition), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	#27
2. Understanding m. "Bell doesn't ring." a) How often is m repeated? _____	#29
3. Conclusion (final answer of subject). "Is the handle up, etc.?" _____(w) Yes. _____(✓) No (it's down). _____(m) Maybe. _____(o) No answer.	#30
4. Justification. _____(o) No justification. _____(e) Equivalence. ...."If the handle is down, the bell won't ring; so the handle has to be down if we can't hear the bell." _____(m) Mistaken reasoning. _____(c) Concrete. ...."I can't see it." _____(v) Strongest. ...."If the handle is up, the bell will always ring; so if the bell doesn't ring, it can't be up." _____v_M ...."If the handle is up, the bell must work." _____v_m ...."You said the bell wouldn't work."	#31-32
5. Subjective evaluation. _____	

FINAL GRADE ☐

④

HOUSE PART GRADE SHEET

Principle IV (Contraposition), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M. _____	
2. Understanding m. _____ "Bell doesn't ring." a) How often is m repeated? _____	#33
3. Conclusion (final answer of subject). "Is the handle up, etc.?" _____(w) Yes. _____(✓) No (it's down). _____(m) Maybe. _____(o) No answer.	#34
4. Justification. _____(o) No justification. _____(e) Equivalence. ...."If the handle is down, the bell won't ring; so the handle has to be down if we can't hear the bell." _____(m) Mistaken reasoning. _____(c) Concrete. ...."I can't see it." _____(v) Strongest. ...."If the handle is up, the bell will always ring; so if the bell doesn't ring, it can't be up." _____v_M ...."If the handle is up, the bell must work." _____v_m ...."You said the bell wouldn't work."	#35-36
5. Subjective evaluation. _____	

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle V (Transitivity 1), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M (1). _____	#44
Understanding M (2). _____ "...if the light is on, the big handle is up." a) Number of times repeated. _____ (Note whether pictures are chosen correctly...#41 and #43.)	#41
2. Understanding m. _____ "...the light is on."	#46
3. Conclusion (final answer of subject). "...can the bell work?" _____(✓) Yes. _____(w) No. _____(m) Maybe. _____(o) No answer.	#47
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. _____ V Repeats major premises in logical way. M (1): If the light is on, the big handle is up. M (2): If the big handle is up, the bell will ring.	#48-49
5. Subjective evaluation. _____	

FINAL GRADE ☐

Principle V (Transitivity 1), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M (1). _____ Understanding M (2). _____ "...if the light is on, the big handle is up." a) Number of times repeated. _____ (Note whether pictures are chosen correctly...#41 and #43.)	
2. Understanding m. _____ "...the light is on."	#51
3. Conclusion (final answer of subject). "...can the bell work?" _____(✓) Yes. _____(w) No. _____(m) Maybe. _____(o) No answer.	#52
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. _____ V Repeats major premises in logical way. M (1); If the light is on, the big handle is up. M (2): If the big handle is up, the bell will ring.	#53
5. Subjective evaluation. _____	

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle V (Transitivity 2), Conditional.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M (1). _____ "If the bell does not work, then the big handle is down."	#55
Understanding M (2). _____ "If the handle is down, the light is off."	#57
2. Understanding m. _____ "...if the bell doesn't ring...."	#58
3. Conclusion (final answer of subject). "...is the light on?" _____(w) Yes. _____(✓) No. _____(m) Maybe. _____(o) No answer.	#59
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. _____(v) Repeats major premises in logical way. M (1): If the bell does not work, the big handle is down. M (2): If the handle is down, the light is off.	
5. Subjective evaluation. _____	

FINAL GRADE ☐

HOUSE PART GRADE SHEET

Principle V (Transitivity 2), Particular.

Items Evaluated Or Graded	Paragraph Number
1. Understanding M (1). _____ "If the bell does not work, then the big handle is down." Understanding M (2). _____ "If the handle is down, the light is off."	
2. Understanding m. _____ "...if the bell doesn't ring."	#62
3. Conclusion (final answer of the subject). "...the light is on." _____(w) Yes. _____(✓) No. _____(m) Maybe. _____(o) No answer.	#63
4. Justification. _____(o) No response. _____(m) Mistaken reasoning. _____(v) Repeat major premises in a logical way. M (1): If the bell does not work, the big handle is down. M (2): If the handle is down, the light is off.	
5. Subjective evaluation. _____	

FINAL GRADE ☐

APPENDIX C

Supplementary Tables

GRADE ONE, CONTROL (Correlation Matrix)
GRADE TWO, CONTROL (Correlation Matrix)
GRADE THREE, CONTROL (Correlation Matrix)
URBAN, CONTROL (Correlation Matrix)
RURAL, CONTROL (Correlation Matrix)
SUBURBAN, CONTROL (Correlation Matrix)
DIFFICULTY INDICES

CONTROL GROUP* CORRELATION MATRIX FOR GRADE ONE

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.02	1.0																	
Chronological Age	.00	.08	1.0																
Suppositional Items	-.29	.18	.16	1.0															
Factual Items	-.20	.40	.10	.82	1.0														
Fallacy Principles	-.07	.43	.13	.64	.82	1.0													
Validity Principles	-.27	.16	.11	.71	.70	.25	1.0												
Chemicals Items	-.16	.46	.11	.76	.89	.89	.58	1.0											
House Items	-.22	.07	.19	.69	.69	.31	.82	.41	1.0										
Verbal I.Q.	-.09	.16	.04	.47	.39	.46	.34	.53	.24	1.0									
Performance I.Q.	-.23	.30	-.05	.17	.06	-.04	.25	.10	.11	.40	1.0								
Total I.Q.	-.20	.26	-.03	.37	.26	.24	.34	.37	.21	.85	.82	1.0							
Inversion	-.11	.38	.10	.62	.73	.93	.15	.78	.24	.41	.01	.25	1.0						
Conversion	-.01	.41	.14	.52	.75	.87	.32	.82	.33	.41	-.10	.18	.62	1.0					
Contraposition	-.30	.26	.16	.67	.60	.25	.85	.56	.63	.43	.31	.42	.18	.30	1.0				
Transitivity	-.15	.01	.04	.55	.59	.17	.86	.43	.77	.14	.12	.17	.08	.25	.46	1.0			
Total Score	-.21	.39	.16	.85	.96	.81	.76	.94	.70	.50	.12	.37	.71	.77	.68	.62	1.0		
Area**	-.16	.58	.32	.08	.11	.21	.08	.27	-.06	.14	.20	.18	.17	.20	.35	-.21	.19	1.0	
Grade																			

*N = 30

**Urban = 1, Rural = 2, Suburban = 3.

CONTROL GROUP* CORRELATION MATRIX FOR GRADE TWO

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.03	1.0																	
Chronological Age	-.28	-.24	1.0																
Suppositional Items	-.24	.49	-.06	1.0															
Factual Items	-.16	.43	-.20	.90	1.0														
Fallacy Principles	-.04	.37	-.22	.86	.91	1.0													
Validity Principles	-.39	.43	.09	.73	.62	.32	1.0												
Chemicals Items	-.20	.38	-.15	.91	.90	.92	.51	1.0											
House Items	-.17	.49	-.06	.81	.80	.62	.78	.56	1.0										
Verbal I.Q.	-.16	.37	-.40	.62	.65	.65	.34	.64	.47	1.0									
Performance I.Q.	-.20	.37	-.13	.40	.34	.33	.29	.41	.22	.62	1.0								
Total I.Q.	-.20	.44	-.30	.59	.56	.56	.37	.60	.41	.91	.88	1.0							
Inversion	.06	.32	-.25	.77	.81	.95	.19	.84	.52	.63	.28	.52	1.0						
Conversion	-.16	.39	-.17	.87	.91	.94	.44	.90	.67	.60	.35	.54	.79	1.0					
Contraposition	-.15	.42	-.07	.55	.49	.26	.75	.34	.69	.35	.24	.34	.23	.26	1.0				
Transitivity	-.43	.36	.16	.69	.57	.30	.94	.51	.69	.27	.26	.32	.13	.45	.48	1.0			
Total Score	-.21	.48	-.13	.98	.97	.90	.70	.93	.83	.64	.38	.59	.81	.91	.54	.65	1.0		
Area**	-.05	.56	.14	.28	.21	.17	.29	.26	.19	.08	.21	.17	.16	.16	.18	.29	.26	1.0	
Grade																			

*N = 28

**Urban = 1, Rural = 2, Suburban = 3.

CONTROL GROUP* CORRELATION MATRIX FOR GRADE THREE

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.04	1.0																	
Chronological Age	-.22	-.12	1.0																
Suppositional Items	.09	.42	-.28	1.0															
Factual Items	-.10	.47	-.09	.89	1.0														
Fallacy Principles	-.16	.23	-.13	.87	.89	1.0													
Validity Principles	.24	.63	-.22	.76	.73	.43	1.0												
Chemicals Items	-.12	.40	-.17	.89	.91	.93	.58	1.0											
House Items	.20	.40	-.16	.77	.74	.56	.82	.49	1.0										
Verbal I.Q.	-.17	.56	-.46	.57	.64	.49	.59	.58	.48	1.0									
Performance I.Q.	-.05	.21	-.26	.39	.44	.31	.44	.37	.38	.72	1.0								
Total I.Q.	-.13	.44	-.41	.53	.60	.45	.57	.53	.47	.95	.90	1.0							
Inversion	-.03	.18	-.22	.83	.84	.93	.44	.85	.58	.46	.31	.43	1.0						
Conversion	-.29	.25	.01	.76	.79	.90	.35	.85	.42	.44	.26	.40	.68	1.0					
Contraposition	.20	.52	-.39	.66	.58	.44	.70	.56	.55	.57	.42	.55	.47	.33	1.0				
Transitivity	.23	.58	-.12	.60	.60	.27	.92	.39	.78	.50	.38	.48	.26	.23	.40	1.0			
Total Score	.00	.46	-.19	.97	.97	.91	.77	.93	.78	.62	.43	.58	.86	.80	.64	.62	1.0		
Area**	.03	.55	.08	.39	.41	.23	.54	.33	.41	.49	.51	.54	.15	.28	.43	.49	.41	1.0	
Grade																			

*N = 29

**Urban = 1, Rural = 2, Suburban = 3.

CONTROL GROUP* CORRELATION MATRIX FOR URBAN AREA

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.19	1.0																	
Chronological Age	-.36	-.29	1.0																
Suppositional Items	-.11	.25	.02	1.0															
Factual Items	-.11	.56	-.13	.75	1.0														
Fallacy Principles	-.01	.31	.01	.73	.78	1.0													
Validity Principles	-.07	.48	.00	.63	.70	.27	1.0												
Chemicals Items	-.16	.31	.08	.77	.84	.92	.50	1.0											
House Items	.21	.57	-.15	.59	.63	.30	.80	.29	1.0										
Verbal I.Q.	.25	.48	-.53	.43	.55	.44	.40	.41	.50	1.0									
Performance I.Q.	.10	.14	-.33	.11	.20	.22	-.03	.13	.09	.66	1.0								
Total I.Q.	.23	.39	-.50	.32	.43	.38	.23	.31	.37	.93	.88	1.0							
Inversion	.04	.25	.05	.76	.70	.94	.23	.83	.32	.38	.24	.35	1.0						
Conversion	-.06	.34	-.03	.57	.76	.91	.29	.89	.21	.44	.16	.35	.72	1.0					
Contraposition	-.11	.24	.11	.63	.60	.34	.80	.53	.60	.30	.00	.18	.34	.29	1.0				
Transitivity	.04	.55	-.18	.34	.48	.05	.79	.21	.71	.39	-.02	.24	-.03	.13	.29	1.0			
Total Score	-.04	.47	.01	.85	.93	.86	.73	.92	.64	.52	.14	.39	.80	.80	.67	.45	1.0		
Area																			
Grade	-.12	-.15	.87	.12	-.04	.14	.06	.18	-.03	-.35	-.26	-.35	.19	.07	.28	-.22	.14		1.0

*N = 29

CONTROL GROUP* CORRELATION MATRIX FOR RURAL AREA

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	-.08	1.0																	
Chronological Age	.28	.42	1.0																
Suppositional Items	.02	.36	.42	1.0															
Factual Items	.01	.19	.40	.87	1.0														
Fallacy Principles	-.03	.12	.17	.70	.82	1.0													
Validity Principles	.06	.32	.49	.80	.67	.19	1.0												
Chemicals Items	.00	.26	.38	.88	.89	.85	.55	1.0											
House Items	.04	.22	.34	.76	.72	.38	.81	.43	1.0										
Verbal I.Q.	-.21	.19	-.07	.30	.27	.19	.27	.33	.13	1.0									
Performance I.Q.	-.21	.18	.09	.34	.24	.05	.43	.27	.24	.59	1.0								
Total I.Q.	-.23	.19	.01	.35	.28	.12	.40	.33	.21	.89	.89	1.0							
Inversion	.06	.04	.08	.52	.75	.88	.11	.72	.29	.12	.01	.06	1.0						
Conversion	-.12	.17	.22	.71	.67	.86	.23	.76	.38	.22	.07	.15	.51	1.0					
Contraposition	-.02	.27	.51	.67	.61	.20	.83	.49	.67	.43	.45	.50	.15	.20	1.0				
Transitivity	.09	.31	.40	.76	.60	.16	.95	.50	.77	.14	.35	.28	.07	.22	.61	1.0			
Total Score	.02	.29	.42	.97	.96	.78	.76	.91	.77	.30	.30	.33	.65	.71	.66	.71	1.0		
Area																			
Grade	.25	.53	.89	.43	.43	.15	.55	.39	.37	.19	.16	.19	.11	.15	.59	.44	.45		1.0

*N = 29

CONTROL GROUP* CORRELATION MATRIX FOR SUBURBAN AREA

	Sex (M = 1, F = 2)	Socioeconomic Status	Chronological Age	Suppositional Items	Factual Items	Fallacy Principles	Validity Principles	Chemicals Items	House Items	Verbal I.Q.	Performance I.Q.	Total I.Q.	Inversion	Conversion	Contra-position	Transitivity	Total Score	Area	Grade
Sex (M = 1, F = 2)	1.0																		
Socioeconomic Status	.18	1.0																	
Chronological Age	.08	-.30	1.0																
Suppositional Items	-.43	.11	.30	1.0															
Factual Items	-.40	.23	.20	.93	1.0														
Fallacy Principles	-.36	.27	.04	.85	.92	1.0													
Validity Principles	-.33	-.08	.49	.76	.63	.34	1.0												
Chemicals Items	-.42	.27	.11	.92	.95	.94	.55	1.0											
House Items	-.36	-.01	.43	.90	.84	.68	.83	.70	1.0										
Verbal I.Q.	-.41	.32	.06	.69	.69	.69	.42	.72	.55	1.0									
Performance I.Q.	-.47	.21	-.02	.40	.33	.26	.39	.29	.42	.49	1.0								
Total I.Q.	-.51	.31	.04	.66	.63	.59	.47	.63	.57	.92	.78	1.0							
Inversion	-.29	.32	.02	.81	.85	.96	.28	.90	.60	.70	.25	.59	1.0						
Conversion	-.42	.18	.07	.81	.91	.94	.38	.88	.70	.59	.24	.51	.81	1.0					
Contraposition	-.24	.08	.35	.59	.45	.21	.80	.38	.65	.39	.40	.44	.17	.24	1.0				
Transitivity	-.33	-.15	.48	.74	.63	.35	.95	.55	.80	.38	.33	.42	.29	.39	.58	1.0			
Total Score	-.42	.16	.26	.98	.98	.90	.72	.95	.89	.71	.37	.66	.84	.87	.53	.70	1.0		
Area																			
Grade	.08	-.28	.91	.34	.21	.06	.53	.15	.43	.13	.09	.14	.05	.06	.30	.56	.29		1.0

*N = 29

DIFFICULTY INDICES
(Proportion of Subjects Who Correctly Answered an Item)

		Inversion						Conversion						Contraposition						Transitivity					
		S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Grade 1	C N = 30	.43	.53	.43	.57	.27	.37	.40	.40	.40	.47	.00	.03	.63	.80	.73	.80	.40	.50	.17	.13	.47	.67	.43	.67
	E N = 30	.33	.43	.50	.57	.17	.23	.40	.33	.37	.40	.00	.00	.67	.80	.73	.83	.30	.57	.17	.30	.67	.73	.57	.63
	Combined N = 60	.38	.48	.47	.57	.22	.30	.40	.37	.38	.43	.00	.02	.65	.80	.73	.82	.35	.53	.17	.22	.57	.70	.50	.65
Grade 2	C N = 28	.57	.79	.54	.64	.43	.50	.54	.61	.54	.61	.11	.11	.86	.96	.86	.96	.50	.79	.25	.29	.68	.64	.71	.82
	E N = 30	.40	.53	.43	.60	.20	.33	.23	.43	.30	.37	.07	.07	.67	.80	.63	.93	.50	.63	.43	.43	.73	.73	.67	.70
	Combined N = 58	.48	.66	.48	.62	.31	.41	.38	.52	.41	.48	.09	.09	.76	.88	.74	.95	.50	.69	.34	.36	.71	.69	.69	.76
Grade 3	C N = 29	.55	.55	.62	.62	.38	.48	.55	.55	.48	.55	.07	.10	.93	.90	.97	.97	.62	.69	.55	.59	.72	.76	.72	.72
	E N = 30	.53	.67	.67	.80	.30	.33	.60	.57	.60	.60	.03	.03	.77	.90	.87	.37	.63	.70	.43	.47	.70	.73	.70	.67
	Combined N = 59	.54	.61	.64	.71	.34	.41	.58	.56	.54	.58	.05	.07	.85	.90	.91	.91	.63	.69	.49	.53	.71	.75	.71	.69
All Grades Combined	C N = 87	.52	.62	.53	.61	.36	.45	.49	.52	.47	.54	.06	.08	.80	.89	.85	.91	.51	.66	.32	.33	.62	.69	.62	.74
	E N = 90	.42	.54	.53	.66	.22	.27	.41	.44	.42	.46	.03	.03	.70	.83	.74	.88	.48	.63	.34	.40	.70	.73	.64	.67
	Total N = 177	.47	.58	.53	.63	.29	.37	.45	.48	.45	.50	.05	.06	.77	.86	.80	.89	.49	.64	.33	.37	.66	.71	.63	.70

NOTE: 'S' = 'suppositional'.
'F' = 'factual'.
'C' = 'control'.
'E' = 'experimental'.